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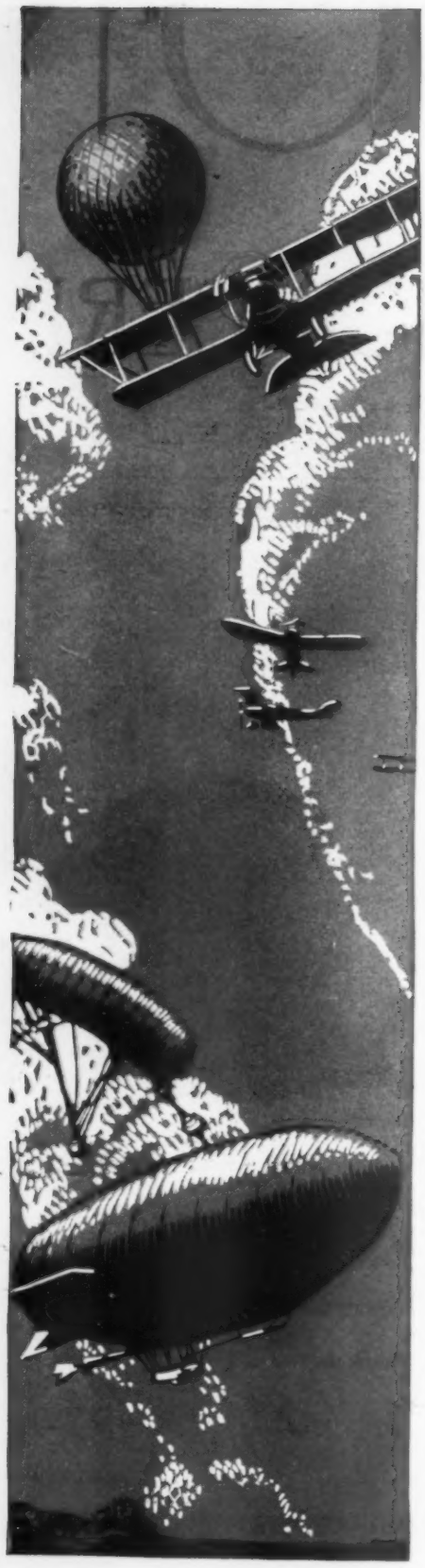

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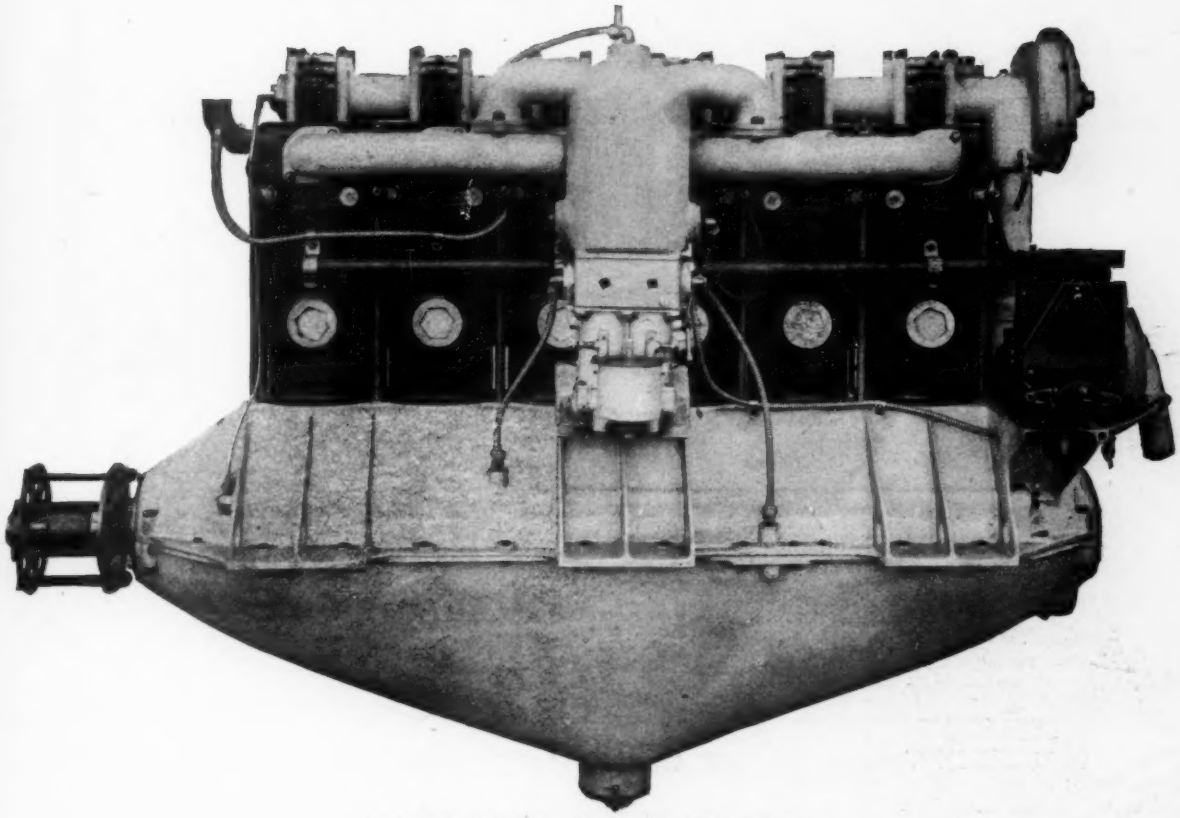

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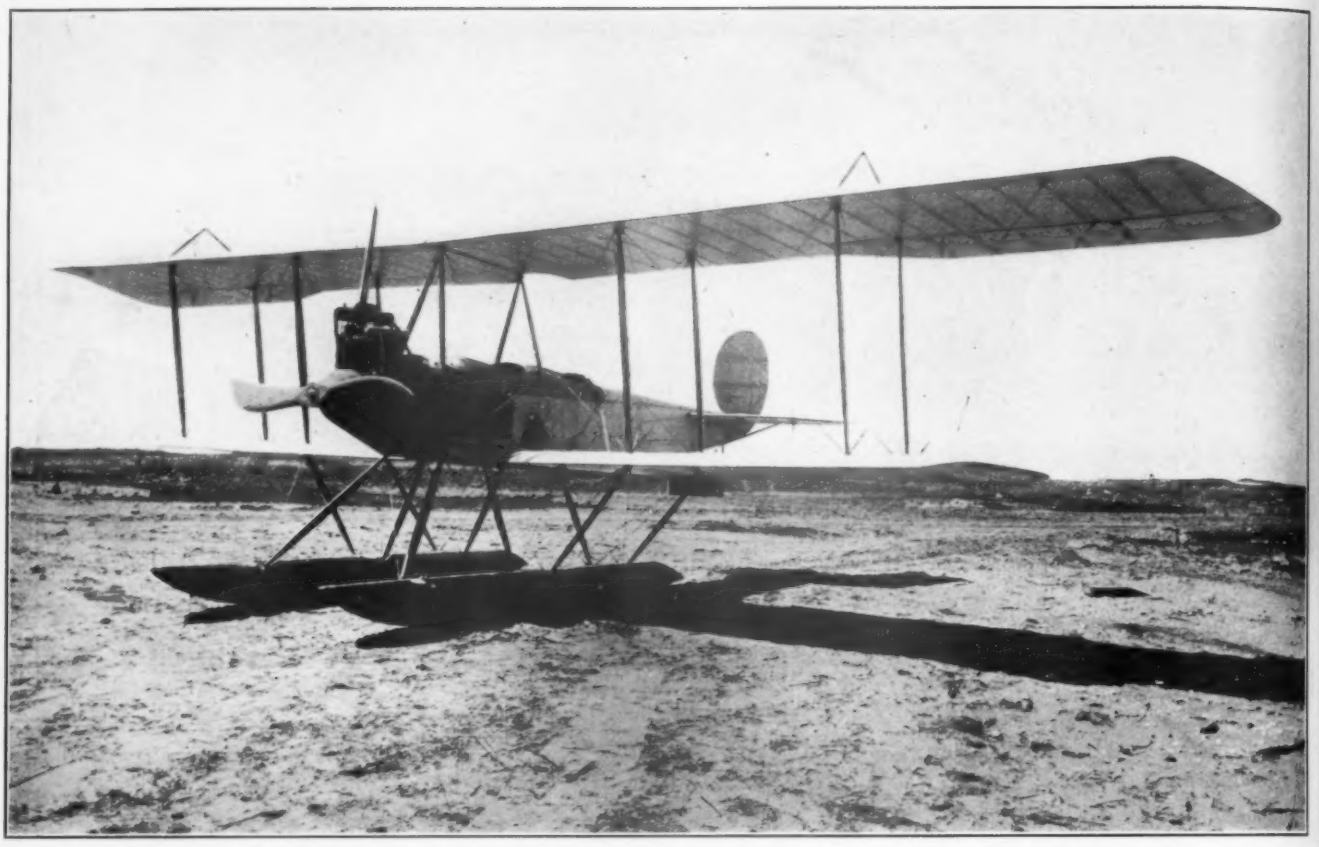

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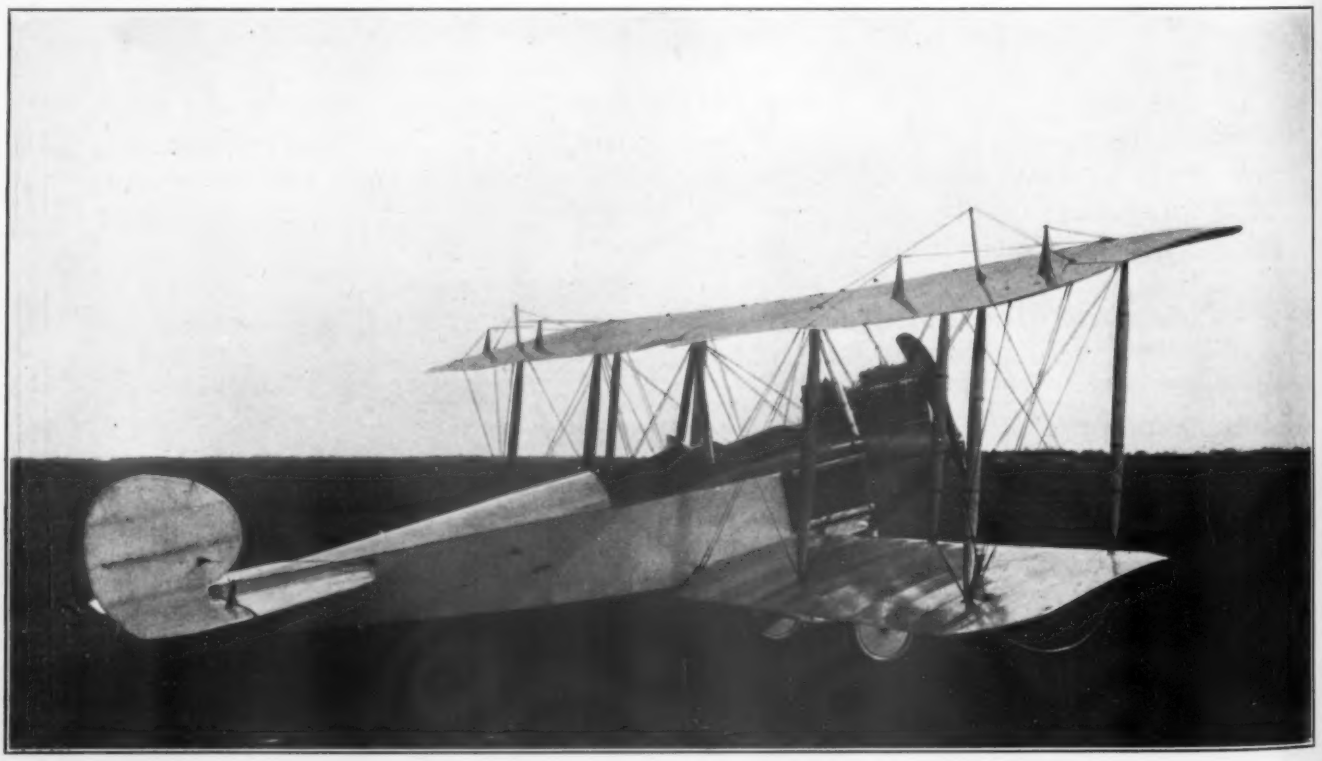

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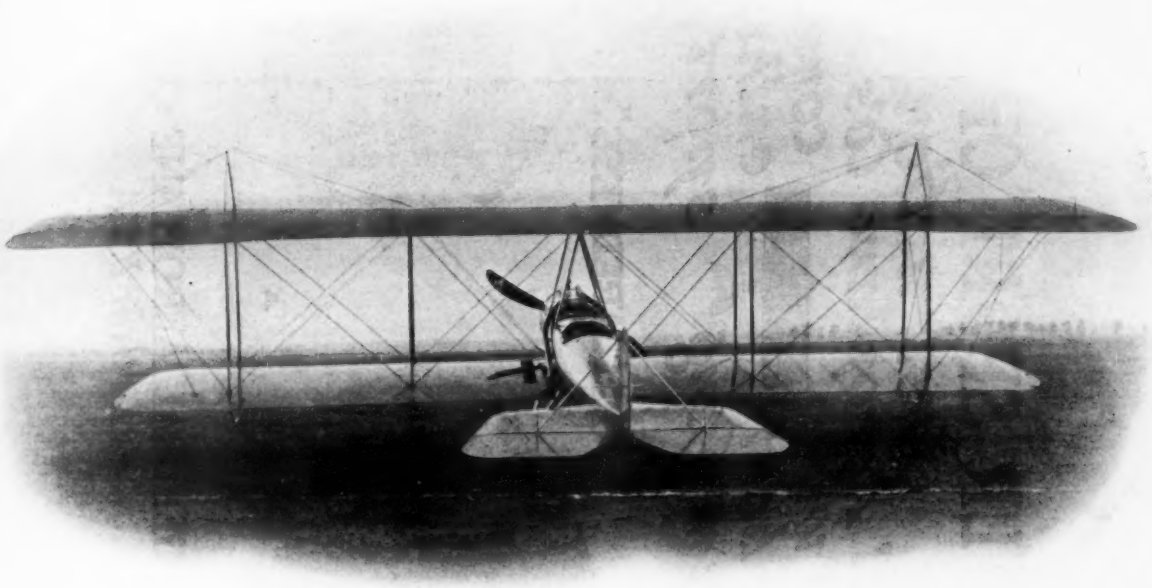

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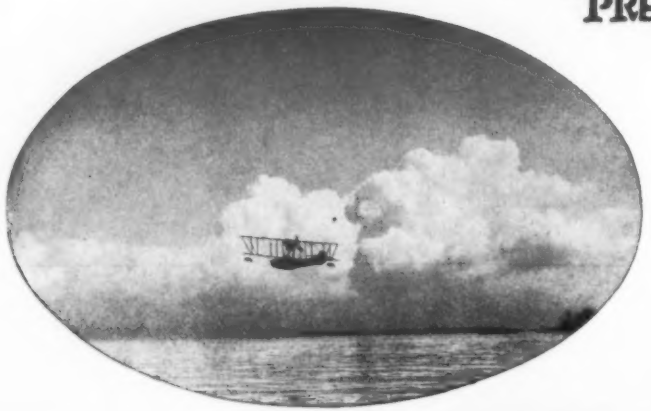

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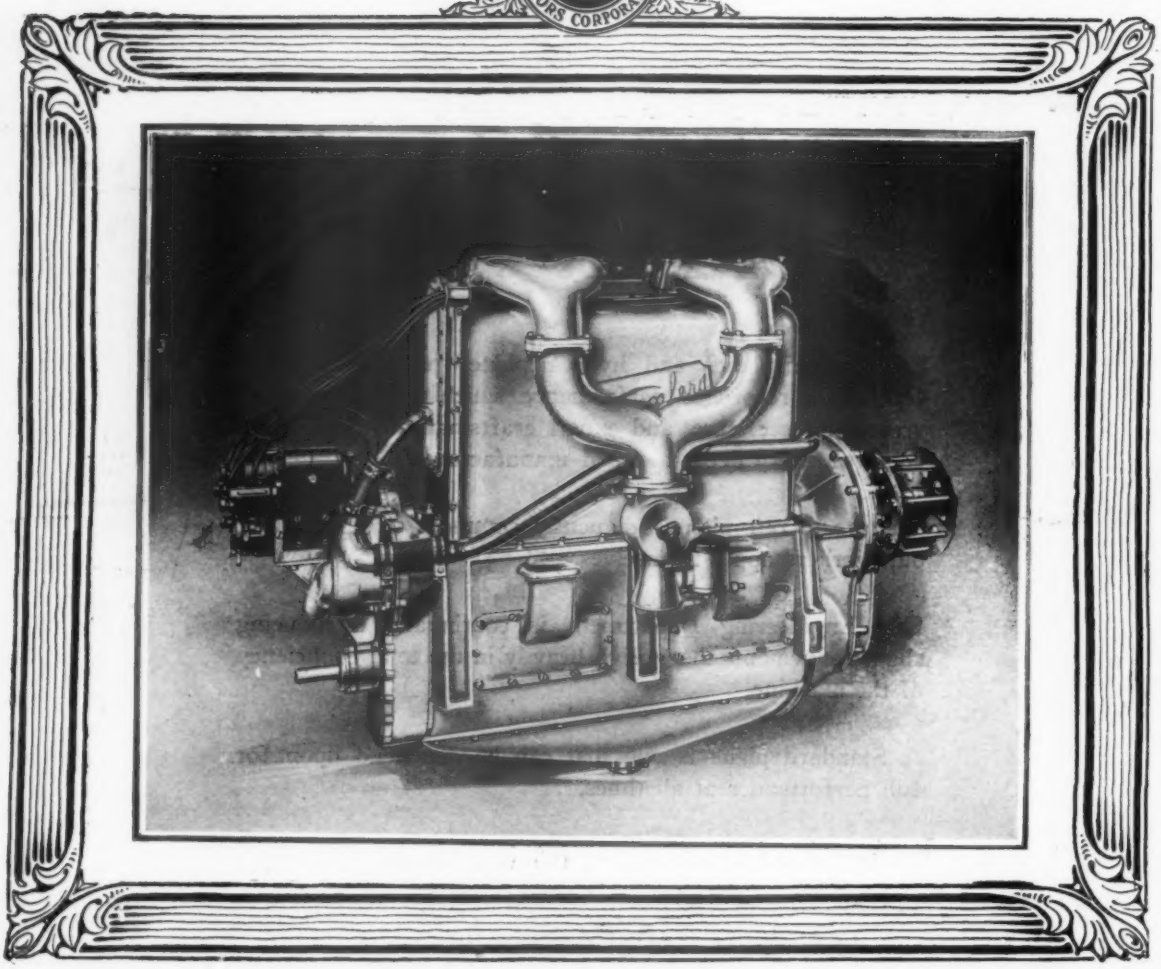

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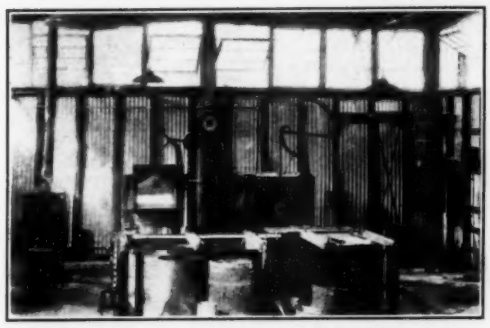

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AVIATION AND AERONAUTICAL ENGINEERING

VOL. II. NO. 9

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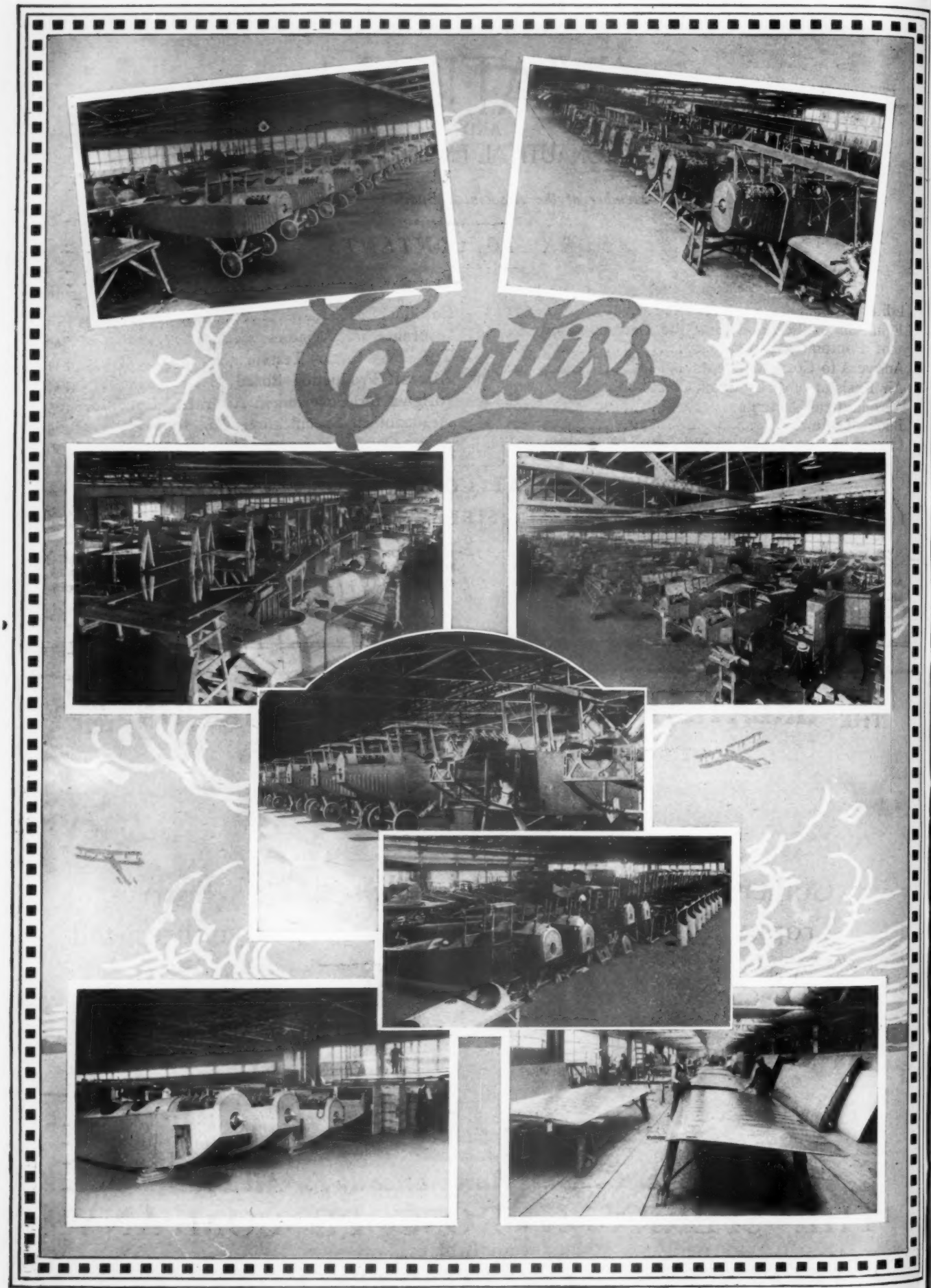

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BUSINESS MANAGER
GEORGE NEWBOLD

Vol. II | June 1, 1917 | No. 9

NOTWITHSTANDING the demands made upon them by the prosecution of the greatest war in history, Great Britain and France have already undertaken the work of inquiring what steps can be taken with a view to the development and regulation of aviation for civil and commercial purposes, after the war.

The following extract from a speech in the House of Commons by the Parliamentary Secretary to the Air Board explains what both countries are endeavoring to accomplish:

"It appeared to the Board, and it has been approved by the Prime Minister, that it should be our duty to investigate the question of aerial civil transport after the war. It will be apparent to honorable members that when the war comes to an end there will be not only a vast number of highly skilled pilots, but there will be a large number of airplanes in the hands of the Services, and a still vaster number of airplanes and aerial engines on order.

"I have quoted the number of people engaged in the air industry today (958 firms, of which the fifty largest employ 66,700 persons). They are more likely to increase than to diminish. Therefore, it does not appear to be unreasonable that the Air Board should take up as a subject of inquiry as far as possible, the uses that can be made of aircraft after the war, and for that purpose it has been decided to institute a committee, of which Lord Northcliffe has been asked to take the chair and has accepted, and it is proposed that the committee should comprise representatives not only of the two Services and of the Air Board, but also of the Board of Trade, the Post Office, the Customs, the Treasury, and from the Dominions, and also, of course, of the manufacturers and designers, and obviously it would be desirable that Parliament should be represented. The terms of reference are as follows: to consider and report to the Air Board with regard to

1. The steps which should be taken with a view to the development and regulation, after the war, of aviation for civil and commercial purposes, from a domestic and Imperial and an international standpoint.
2. The extent to which it will be possible to utilize for the above purposes the trained personnel and the aircraft the conclusion of peace may leave surplus to the requirements of the Naval and Military Air Services of the United Kingdom and Overseas Dominions.

"The Committee corresponds to a similar body which has already been created in France under the presidency of M. d'Aubigny. It was set up by the Ministry of Commerce, and was appointed to consider the routes to be followed in France, the Colonies and in Allied countries, types of machines to be employed, type of postal car or carrier, bases, relay stations, and the recruitment of personnel, as well as the questions of the purchase of hangars, airplanes, engines, etc., for the military authorities."

It is significant that the British Committee is headed by Lord Northcliffe, owner of the London *Times,* who has been a consistent and powerful advocate of the Air Services, and whose fearless and constructive criticism is considered by many well informed men to have saved England from serious mistakes, if not utter failure in the conduct of the war.

Our Government should at once take steps to provide for a similar investigation to be undertaken in this country. A Federal Commission should be authorized, organized somewhat along the lines of the British Committee, or the task should be undertaken by the National Advisory Committee for Aeronautics.

Unless this is done, and unless some definite steps are taken to solve these important problems relating to the future commercial uses of aircraft, the United States will find itself, at the conclusion of peace, with an immense industry built up during the war, ready to develop the commercial airplane, but without definite plans and uses for the facilities they have acquired. The time to prepare for the future is today.

Confusion Should Be Cleared Up

One of the greatest dangers to the present status of aviation in this country is the overorganization by committees. The President appointed the National Advisory Committee for Aeronautics to supervise and direct the scientific study of the problems of flight with a view to their practical solution. A joint board of the Army and Navy has been at work on the engineering problems of design and specifications. Civilian boards and committees have been appointed by organizations to advise the government, and now the Council of National Defense creates an Aircraft Production Board to formulate the government's aircraft policy and carry it into effect. A statement regarding the work of the board appears elsewhere in this issue. The general impression prevails that this board will have to do with purchasing, and will have general supervision of production.

In this connection it would be well if a clear statement were made outlining the authority of each board and its special functions. The law creating the Council of National Defense makes it an advisory board which works through the regular departments of the government.

To do aeronautical business with the government at the present time requires a knowledge of the intricacies of not only the Army and the Navy bureaus, but of these various committees whose spheres are not clearly defined. A definite statement of all such work will be of great assistance at this time.

Flotation of Pontoons and the Determination of Pontoon Position

By Edward P. Warner and George M. Denkinger

Consider an airplane, of total weight W, supported by two pontoons. Then $\frac{W}{2}$ = weight supported by each pontoon, and $\frac{W}{2\rho}$ = volume of water displaced by each pontoon, where ρ is the density of the fluid displaced.

The weight of the machine and the buoyancy of the pontoons are necessarily equal in magnitude. Both are vertical forces, the first of which is applied at the center of gravity of the machine, the second at the centers of buoyancy of the pontoons, these points corresponding with the centers of figure of the submerged volumes. Since the structure of an airplane is always symmetrical transversely, and since we shall make no attempt to investigate transverse stability, we need not take account of the lateral position of the floats in making our calculations, and we shall consider only one float.

If the center of gravity and the center of buoyancy do not lie on the same vertical line, the forces will form a couple which will rotate the machine in the water until the center of buoyancy has moved forward or back to lie directly under the center of gravity.

Consider the pontoon shown in Fig. 1. It has been seen that the amount of water to be displaced is $\frac{W}{2\rho}$, where W is the weight of the machine and ρ the density of the fluid. The pontoons are to give an excess flotation of 67 per cent (as required in U. S. Army Specifications No. 1002), so the first step is to design a pontoon of volumetric capacity $.83 \times \frac{W}{\rho}$. The next step to consider is the determination of the waterline of the pontoon. Assume a waterline estimated to give the required flotation; to check this assumption, divide the length of the pontoon into sections with stations; for convenience, we shall take nine stations, including those at the extreme ends, numbered from 1 to 9. The reason for selecting this number will be shown later. We have now to compute the submerged volume of the pontoon, and this may be readily done by the application of Simpson's Rule, which is as follows: $V = \frac{1}{3} \times s\ (a + 4b + 2c + 4d + \ldots + 2x + 4y + z)$, where s is the distance between stations, and a, b, c, etc., are ordinates at stations. In this particular case s is one-eighth the length of the pontoon in feet, and a, b, c, etc., are the transverse areas of the submerged portion of the float at stations 1, 2, 3, etc., in square feet. These areas, if the section is not rectangular or trapezoidal, may also be computed by Simpson's Rule, letting a, b, c, etc., be the widths of the pontoon at the section in question in and at various equally spaced distances below the waterline. It should be noted that, in order to apply Simpson's Rule to any case, there must be an odd number of stations. The volumes and areas may, of course, be found much more easily by the use of the planimeter or integrator, if these instruments are accessible.

Suppose that, on trial, the submerged volume with the assumed waterline is found to be greater than the required displacement. Assume a second waterline below the first, and compute as before. If this one is not near enough, take a third. Then, having three points close together, it will be possible to draw that portion of the curve of displacements, plotting displacement against height of waterline. It is a good plan to plot this curve in any case, as it is then possible to read off the height of waterline directly for any alteration in displacement.

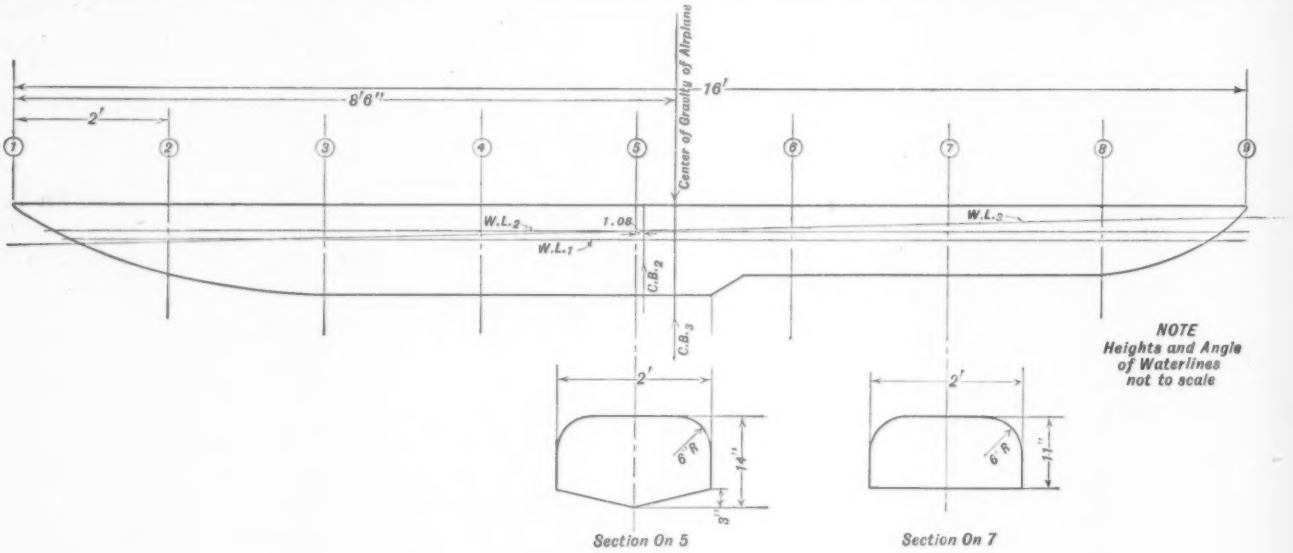


FIG. 1

Location of the Center of Buoyancy

To find the center of buoyancy of the pontoon, the area of the submerged cross-section is computed at each station, exactly as is done in finding the height of the waterline. The area of each station is then multiplied by its distance from some convenient station, thus giving the moment of the section in question about this station. It is advisable to use a station about midway between the bow and stern of the pontoon as a base, and to use the distance between stations as the unit of length,—that is, if there are nine stations, two feet apart, and numbered from 1 to 9, No. 5 should be taken as a base, and the moment arm of station 3 should be taken as two, the number of station intervals, and not as 4 ft., the actual distance from the base. The moments of stations forward of the base have a plus sign, while those aft of that point are negative.

After all the moments have been secured, we must proceed to compute the total moment of the hull about the base station. To do this, assuming that we have no access to an integrator, we must again resort to Simpson's Rule. Employing this, we find, separately, the moment of the forebody, and that of the afterbody. Then adding these algebraically, the first being positive, the second negative, we have the total moment of the hull; to reduce this moment to the proper units, it is multiplied by the distance between stations.

This moment may be considered as exerted by the entire displaced volume concentrated at the center of buoyancy, and may be written $V \times x$, where V is the displaced volume in cubic feet and x the distance from the C.B. to the base section, in feet. Then $x = \frac{M}{V}$, and, M and V both being known, x can readily be obtained. It is necessary to observe caution in manipulating this equation, lest a mistake be made in signs. A check can be made from the fact that, if the moment of the afterbody is numerically greater than that of the forebody, the C.B. will be aft of the base, and vice versa.

The total moment of the pontoon can be found directly from the curve of areas by the use of an integrator. The integrator straight edge is set to coincide with the vertical ordinate corresponding to the area of the base section, and the moment wheel is read directly to give the moment for the entire fore- or afterbody.

Determination of Inclination of Waterline

The next problem to be attacked is that of finding the waterline when the position of the pontoon with respect to the center of gravity of the machine is fixed. In this case, we cannot assume that the waterline is horizontal or that it has any other particular inclination, as the float will assume a position such that the C.B. and the C.G. lie in the same vertical line. We have, therefore, to determine both the height and inclination of the waterline.

The first step is to find a horizontal waterline which will give the proper displacement and then to locate the C.B.

with that waterline, utilizing the methods already described. We then measure the distance between this trial C.B. and the position which the C.B. must ultimately be brought to occupy, and designate this as x.

As a first approximation, we may consider that the float can be rocked about a transverse axis passing directly through the C.G. of the waterline without effect on the displacement. This is very nearly true for pontoons of conventional section, so long as the angle of rock is small. When the pontoon is rocked through a small angle θ a wedge-shaped portion, W_e, will emerge from the water at one end, the buoyancy of this portion thus being lost, and a wedge of equal volume W_i, will be immersed at the other end. These wedges and the forces acting are shown in Fig. 2.

We next take moments about the transverse axis of rock. To determine the moments of the wedges of immersion and emersion, consider them as broken up into small strips by vertical planes parallel to the axis. Then if x is the distance of any one of these strips from the axis, its height is $x\theta$, and if the breadth of the waterline at that point is b, and the length of the strip Δx, as in Fig. 2, the volume is $bx\theta\ \Delta x$, and the moment about the axis is $bx^2\theta\ \Delta x$. It can be shown by a simple application of the calculus that $\Sigma(bx^2\ \Delta x)$ is identical with the moment of inertia of the waterline section about an axis through its C.G. Since the two wedges are opposite in sign and on opposite sides of the axis, the numerical values of their moments are to be added, and the total moment is correctly given by the moment of inertia of the entire waterline section, from stem to stern, multiplied by the angle of rock.

The moment of inertia can be obtained very easily by means of an integrator. If no such instrument is at hand, however, we may compute the values of bx^2 for several uniform values of x. The application of Simpson's Rule to these quantities, considering the values of bx^2 as ordinates of a curve, the abscissae of which represent values of x, will then give the moment of inertia, which corresponds to the area under the curve.

Since the forces acting on the float may be reduced to the buoyancy and the weight, acting at the C.B. and the C.G., respectively, it must be possible to express the change of moment, the value of which we have found from the immersed and emersed wedges, as due to the change in position of the C.B.

It is desired to shift the C.B. through the distance x, in order to bring it into the vertical line with the C.G. The force acting at the C.B. is always equal to the displacement of the float, which is given in cubic feet, since linear dimensions are used throughout in place of weights in computing the moments of the wedges. The moment due to shifting the C.B., then equals Vx, and this must equal $I\theta$, the moment due to the wedges. It is then evident that θ, the angle through which the float must be rocked about a transverse axis in order to shift the C.B. through the distance x, is equal to $\frac{Vx}{I}$

θ is, of course, given in circular measure. The value in degrees can be secured by multiplying this by 57.3. All other dimensions must be kept in feet. (Note 1).

After this work has been done we must draw a new waterline, passing through the C.G. of the old one, and making an angle of θ radians with it, and carry through the calculation for the determination of displacement and C.B. again, as the determination of θ is not absolutely exact. If it does not come correct this time another value of θ must be computed and a second rotation made, but this is not likely to be necessary.

If the pontoon is of constant breadth throughout its length and of nearly rectangular cross-section, the waterline section is a rectangle, and the work is enormously simplified. If the waterline length is l and the breadth b the moment of inertia $= \frac{bl^3}{12}$, and $\theta = \frac{12Vx}{bl^3}$, where V is, for a two-float machine, $\frac{W}{2\rho}$, W being the weight of the machine.

As a practical illustration of the use of the foregoing formulas we shall work out an illustrative example, as follows:

Assume a machine of total weight of 1920 lb., supported by two pontoons. It is then evident that each pontoon must displace $\frac{1920}{2 \times 64}$ or 15 cu. ft. (in salt water). If, in addition, 67 per cent excess flotation is required the total volumetric capacity of each pontoon must be $15 \times \frac{5}{3}$, or 25 cu. ft.

As has been stated before, the next step is to ascertain a waterline at which the pontoon will displace exactly 15 cu. ft., when the machine is resting normally upon the water in a horizontal attitude. In this problem the C.G. of the machine is considered as fixed and the true waterline is to be determined. This is the most difficult case, as the inclination of the waterline is generally decided on initially and the C.B. and C.G. of the machine made to lie in the same vertical (this is readily done by moving the pontoon, the C.B. of which has been determined, until the foregoing relation is satisfied). In this problem, we shall employ a straight-sided, V-bottom, pontoon 16 ft. long, shown in Fig. 1. The pontoon is fixed in such a position that the line of action of the weight of the airplane is 8½ ft. from the nose. Therefore the C.B. must also be at this distance.

No. of station.	Total area. (Sq. ft.)	Area of section below 1st assumed waterline. (Sq. ft.)	Area of section below 2nd assumed waterline. (Sq. ft.)
1	0	0	0
2	1.48	0.65	0.73
3	1.98	1.15	1.23
4	1.98	1.15	1.23
5	1.98	1.15	1.23
6	1.73	0.90	0.98
7	1.73	0.90	0.98
8	1.73	0.90	0.98
9	0	0	0

These areas are obtained directly by breaking the sections up into rectangles, triangles, and segments.

Then, applying Simpson's Rule to the second column of this table, we have V', the total volume, $= \frac{1}{3} \times 2 \times [0 + 4 \times 1.48 + 2 \times 1.98 + 4 \times 1.98 + 2 \times 1.98 + 4 \times 1.73 + 2 \times 1.73 + 4 \times 1.73 + 0] = 26.04$ cu. ft. The excess flotation is therefore ample.

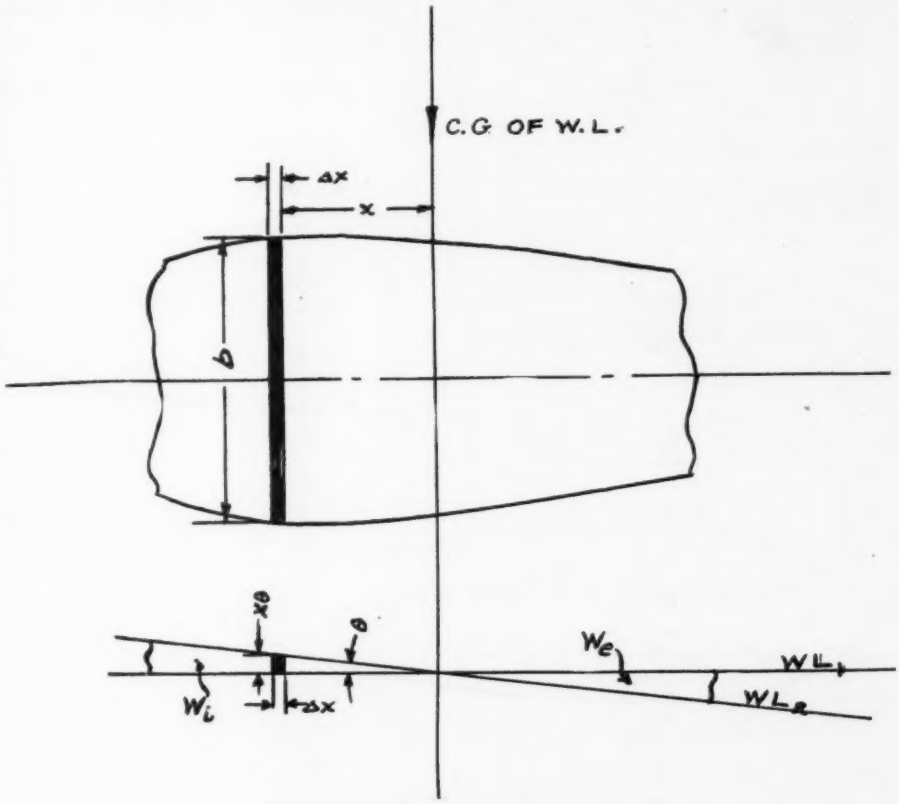


FIG. 2

Treating the figures of the third column similarly we find that V, the volume below the assumed waterline, $= 13.87$ cu. ft. Since this is too small, we try another waterline, half an inch higher, the areas below this line being given in the fourth column of the preceding table. For this, $V = 15.04$ cu. ft., which is as nearly correct as we can expect to get.

To find the longitudinal position of the C.B., we take moments about station 5, as heretofore shown.

No. of station.	Moment about station 5.
1	0
2	+2.19
3	+2.46
4	+1.23
5	0
6	—0.98
7	—1.96
8	—2.94
9	0

These moments are obtained by multiplying the areas given in the fourth column of the preceding table by the num-

ber of station intervals intervening between the station in question and No. 5.

Treating the plus moments by Simpson's Rule, $M_1 = \frac{1}{3} \times 2 \times 2 \times [0 + 4 \times 2.19 + 2 \times 2.46 + 4 \times 1.23 + 0] = 24.80$.

For the negative moments, $M_2 = -\frac{1}{3} \times 2 \times 2 \times [0 + 4 \times .98 + 2 \times 1.96 + 4 \times 2.94 + 0] = -26.13$. Summing algebraically, $M = -1.33$

$$x = \frac{M}{V} = \frac{1.33}{15} = .09 \text{ ft.}$$

The C.B. is therefore .09 ft. aft of station 5. Since the C.G. of the machine is 8.5 ft. back of the bow of the pontoon, it is necessary to move the C.B. .41 ft. aft. As the waterline section is rectangular, the simplified method can be applied.

$$\text{Thus } \theta = \frac{12Vx}{bl^3} = \frac{12 \times 15 \times .41}{2 \times (14.9)^3}$$
$$= .011 \text{rad.} = 0.6 \text{ deg.}$$

We therefore draw a new waterline, $W.L._2$, making an angle of 0.6 deg. with $W.L._1$, and cutting station 5 at the same point. Since the angle was so extremely small, it is unnecessary to repeat the computations. This method should always give the height of the waterline correct to within 1-10 inch.

Note: This expression takes account only of the moment due to form, and not of the moment due to change in position of the C.G. during rotation. To make the analysis more complete, we shall consider the rotation as taking place about the original center of buoyancy. Then, when the machine is inclined forward through the small angle θ the center of buoyancy moves forward, as has been seen, but the center of gravity also moves with respect to the original C.G., and a vertical through the C.G. no longer passes through that spot, but a distance $h\theta$ in front of it, where h is the vertical distance between the C.G. and the original C.B. The true moment arm is therefore $\frac{I\theta}{V} - h\theta$, and $\theta = \frac{Vx}{I - Vh}$. This correction may be quite important in the case of body hydros with a high C.G., necessitating an increase of from 10 to 20 per cent in θ.

Answers to Correspondents

O'GORMAN'S REPORT ON DIRIGIBLE SHAPES

British Report 1911-1912. No. 43

O'Gorman subdivides the resistance of a fair shaped body into two parts:

(1) Skin friction, R_f

(2) head, form or turbulence resistance R_H

The total resistance $R_t = R_b + R_H$.

Experiments were conducted by towing 18-ft. models and measuring the total pulls at a range of velocities from 8 ft. to 25 ft. per second. Plotting the total resistance found in this way against velocity, the law for R_t deduced within these limits of velocity is

$$R_t = KAV^{1.86}$$

where K is a constant varying with each fair shape, R_t is in lbs., V in ft./sec., and A is the maximum cross-section area. The curve for skin friction R_f is deduced from Zahm's formula: $R_F = .00000778\ a\ L^{-.07}\ V^{1.83}$, where L = length in feet, a = area in square feet of side elevator, V is in ft./sec., and R_b is in lbs.

Deducting R_b from R_t a curve is established for R_H so that $R_H = e\frac{\psi}{g}AV^2$, where ψ = a constant, ρ = density of air, A = maximum cross-section area of body.

The experiments showed that ψ varied only from 0.21 to 0.26. The results of the tests are shown in the figure. Zahm's friction formula, and the method employed by O'Gorman are both open to criticism, nevertheless the results are sufficiently accurate for practical application.

In going to a full size application of the results, the following method would be employed: R_H would be taken in accordance with the above results and the R_b curve would be extended in accordance with Zahm's formula to full size dimensions and velocities.

C. G. T.—"Pitch" is a much abused term, and may be defined in a number of different ways. The geometrical pitch, which is the most commonly used, is equal to $2\pi r \times \tan\alpha$ for any element of the propeller blade, where r is the distance from the center of the hub and α is the angle between the chord of the element and a plane perpendicular to the axis of the propeller. This expression varies along the blade in practically all propellers, and it would therefore be incorrect to give a single figure for the geometrical pitch. When such a figure is given, it usually represents the pitch at the widest portion of the blade or somewhat nearer the tip.

The effective pitch, which is somewhat less than the geometrical, is equal to the distance of advance per revolution of the propeller, or V/n, where n is the number of revolutions per minute. The defect with this is that it depends on the characteristics of the airplane itself, and the same propeller will have different effective pitches on different machines.

The mean experimental pitch, more scientific than either of the others, but more difficult to obtain, is equal to the rate of advance per revolution when the propeller is giving no thrust.

To give a concrete example, if we have a propeller the diameter of which is 8 ft., the tip angle 20 deg., the geometrical pitch at the tip will be $2 \times \pi \times 4 \times \tan 20 \text{ deg.} = 9.15$ ft.

The design of a propeller to fit an engine is a rather complex problem, and your second question cannot be answered offhand in a completely satisfactory manner. The effective pitch of your propeller must be 5.8 ft. (assuming the engine to run at 1200 r.p.m., since you gave no data on this point). As mentioned above, the geometrical pitch is a little greater than the effective, and a geometrical pitch of between 7 and 8 ft. should therefore give a good propeller efficiency, provided that the blade form, sections, etc., are otherwise suited to your engine and plane.

Silencing the Airplane Engine

In a paper recently presented to the Aeronautical Society of America, Leon Cammen discussed the silencing of airplane engines. Mr. Cammen called attention to the great increase in back pressure due to changes in the direction of flow of the exhaust gases. Because of this increase, it is desirable that the muffler be a direct prolongation of the manifold and that the flow from the valve passages into the manifold be as nearly as possible in a straight line.

Mr. Cammen describes a new type of muffler which completely fulfills the conditions laid down. The muffler proper containing the baffle-plates, is preceded by two expansion chambers of progressively increasing size, and these have numerous small outlets to reduce the gas velocity.

Air Resistance of Cylinder Combinations*

By T. H. Huff

During the past year Messrs. T. Wong and T. Yu conducted the following investigation to determine the shielding effect of certain tandem wire or cylinder combination commonly met in airplane trussing. The work was supervised by Dr. Hunsaker at the Aerodynamical Laboratory of the Massachusetts Institute of Technology.

Specimens

Round wood rods of maple, turned to the nearest hundredth of an inch, were employed to represent the wires. The models were 18 in. in length and of ½, ¾ and 1 in. diameter. A second series, in the form of boards, 1 in. in thickness and

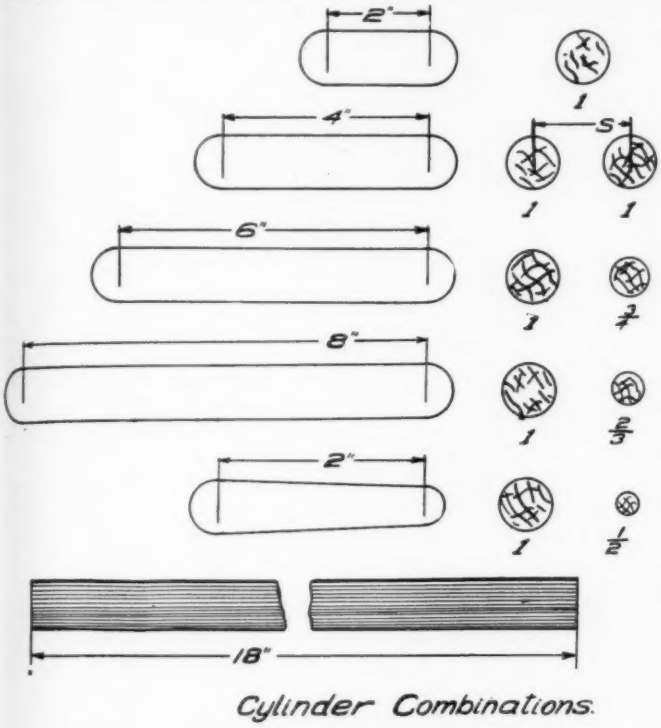


FIG. 1. FILLED IN GAP CYLINDER COMBINATIONS

18 in. in length, with rounded edges, typified various wire spacings with filled in gaps.

All models and combinations are shown in Fig. 1.

Mounting

A special apparatus (Fig. 2) was designed to support the models in a horizontal plane normal to the wind. A slotted T head permitted an adjustment of the gap between the rods or supported the large flat models.

Testing

In this particular case, the recording balance in the Institute wind-tunnel was arranged to measure only the resistance or drag of the model, a force parallel to the wind. The following investigations were recorded:

(1) The determination of the resistance of the supporting device alone and the precision of the alignment required.
(2) The resistance of single cylinders of different diameters subjected to a series of wind velocities.
(3) The resistance of two cylinders in tandem:
  (a) The effect of the increase in the gap or space between two rods of equal diameter.
  (b) The effect of variation in gap between two cylinders, the rear one being smaller in diameter than the front.
(4) Reduction in resistance caused by filling in the gaps between the tandem rods.
  (a) Different gaps with equal diameter cylinder.
  (b) Tapering board to represent filled in gap with smaller wire in rear of tandem.

Results

(1) Determination of the resistance of the supporting apparatus: the apparatus alone was mounted on the wind-tunnel balance and its resistance measured at various wind velocities. In order to determine the effect of alignment of the apparatus upon the results of the test, the mounting was turned 2 deg. to either side of the correct parallel position and the resistance recorded. An increased resistance of 8 per cent was observed for a 2 deg. change in alignment. From previous experiments, an accuracy of alignment of ¼ deg. was found to be easily obtained, so that a variation might be expected of possibly 1 per cent in the resistance of the apparatus, which, in turn, was approximately 15 per cent of the average resistance recorded in these investigations. The resultant error should, therefore, be negligible.

(2) Resistance of a single cylinder: with the apparatus employed, the flow of air around the end of the test specimen was more or less restricted. To avoid a large error that might otherwise have been introduced in the comparison of single and tandem wires, the single specimens were mounted on the supporting frame and their resistance determined at velocities from 12 to 35 m.p.h.

The coefficient "K" from these tests was plotted against the product of diameter (in feet) and wind velocities (in feet per second) i.e., *D.V.* In Fig. 3, the comparative resistance of the cylinder combination is based upon these values for the single cylinders.

The assumption that the coefficient "K" is a function of *D.V.* is based upon the principle of dynamical similarity (Note 1). The dimensional effect in the results is, therefore, eliminated.

Note 1: AVIATION AND AERONAUTICAL ENGINEERING, Page 329, December 15, 1916.

(3) Resistance of cylinder combinations: (a) Cylinders of equal diameter with wiring spacing; specimens employed were two ½ in. diameter cylinders. The front cylinder was placed in the foremost position in the slotted T head, and the rear placed next to it, the smallest allowable spacing in this case being one diameter, distance measured from center to center of cylinders. The rear rod was then moved progressively away from the front one and the resistance recorded in each case.

(b) Cylinder of different diameter with varying spacing: the specimens were mounted and the adjustment varied as above, the rear cylinder, however, being of smaller diameter than the front. The three combinations were:

	Front in.	Rear in.	Ratio
(2)	1	¾	1 : ¾
(3)	¾	½	1 : ⅔
(4)	1	½	1 : ½

The tests were all run at a wind velocity of 30 m.p.h. and

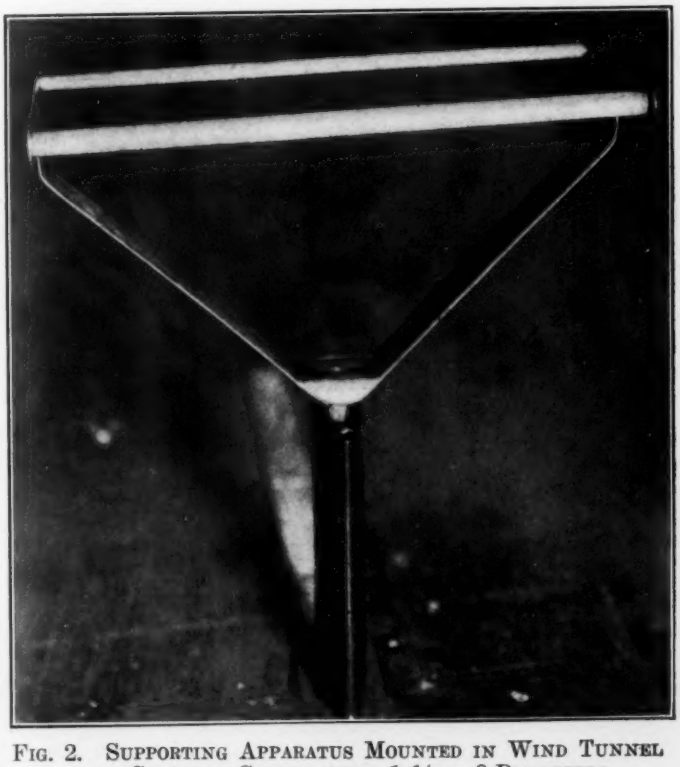
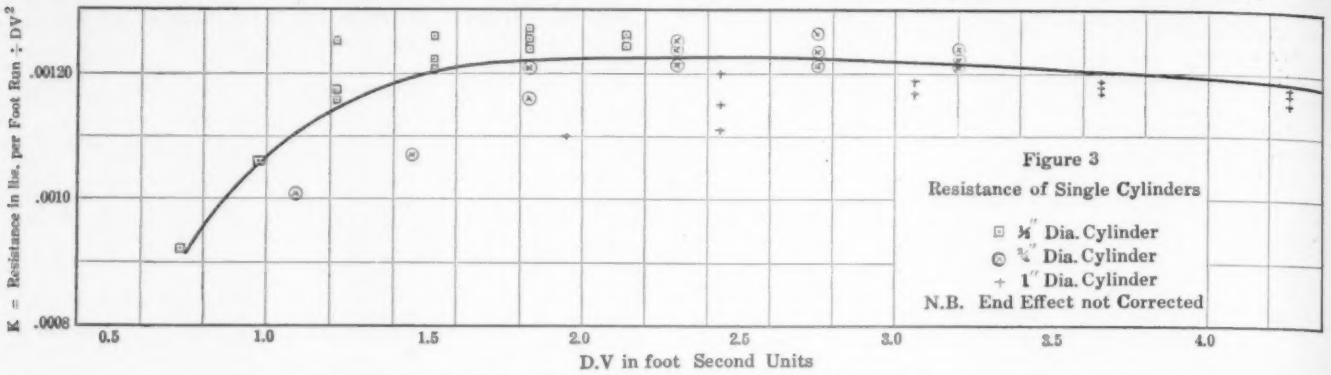


FIG. 2. SUPPORTING APPARATUS MOUNTED IN WIND TUNNEL WITH CYLINDER COMBINATION, 1:½ AT 8 DIAMETERS SPACING

* Abstract of a Thesis by T. Wong and T. Yu.

the value of "K" calculated from the formula $R = KDLV^2$ where R = measured resistance of combination in pounds, D = diameter of front cylinder in feet, L = length of specimen in feet (1.5), V = wind velocity in feet per second (44).

In combinations (1) and (3) the maximum diameters being



respectively ½ and ¾ in., the coefficient "K" has been reduced to that of a 1 in. diameter cylinder at 30 m.p.h. by the *D.V.* law. This permits of a comparison of all four combinations, with the value of "K" for the single 1 in. diameter cylinder at 30 m.p.h. Fig. 4 is a plot of these comparisons where the resistance of the single cylinder is taken as unity and the per cent variation plotted against cylinder spacing.

(4) Resistance of cylinder combination with filled in gap: (a) it was thought a reduction in resistance might be obtained by filling in the space or gap between the tandem rods to assimilate the practice of wrapping fabric or imbedding in wooden "stream lines" wires where they occur in pairs. Four filled in gap combinations, shown in Fig. 1, were tested respecting spacings of 2, 4, 6, 8 diameter of the 1:1 ratio, represented by boards 1 in. thick with semi-circular ends.

(b) One specimen was tested to represent the 1:¾ ratio with a spacing of 4 diameters to ascertain if any marked improvement resulted from filling in the space of this type. The 1:¾ ratio was chosen since it would represent more closely possible practice.

The length of all boards was 18 in., as in the previous tests. All specimens, excepting the tapering type, were tested with one edge, and then the other facing the wind, and the results averaged in order to reduce to a minimum all errors due to mounting and workmanship.

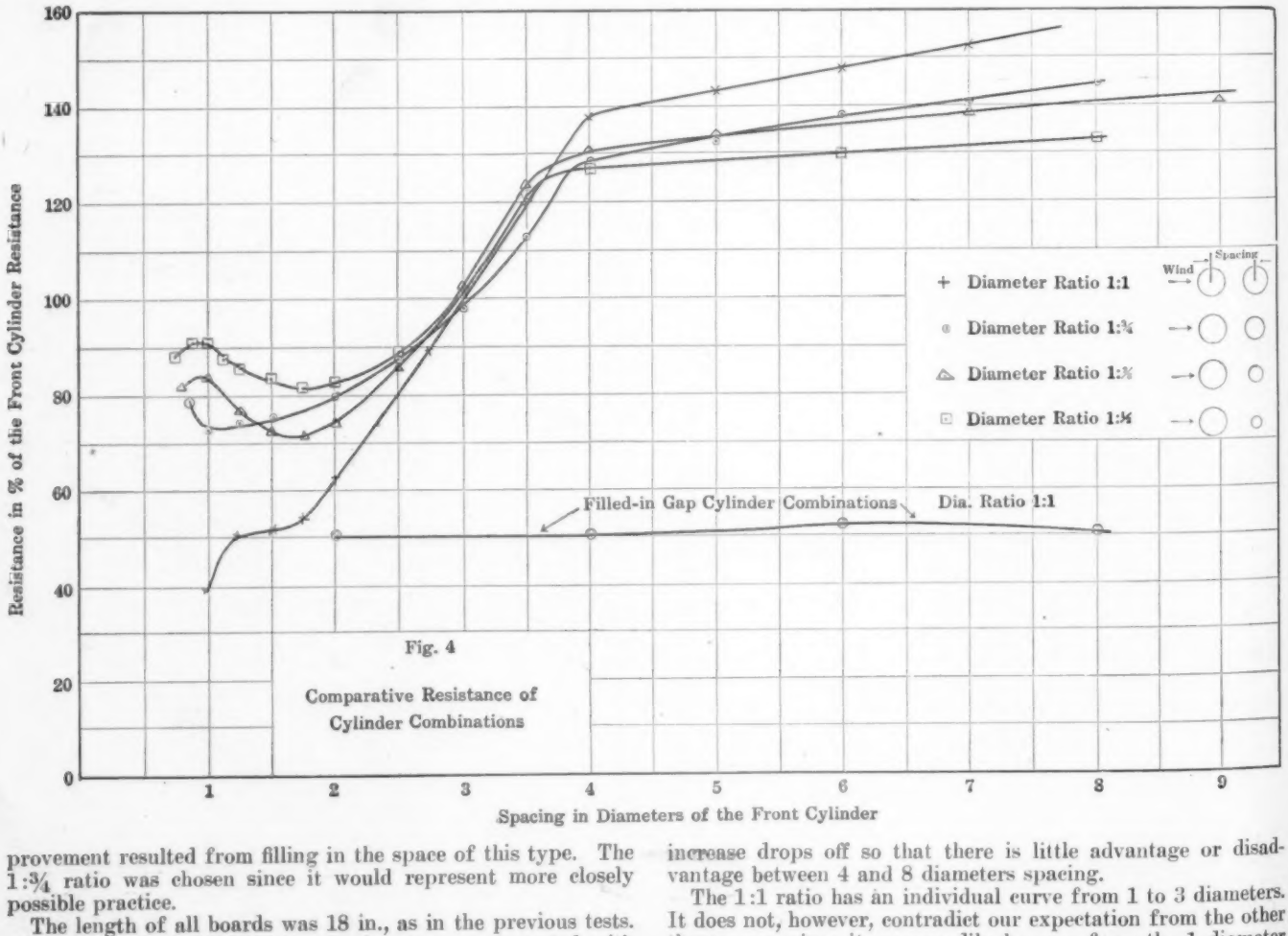
The results of (a) are plotted in Fig. 4 (filled in gap combination). The present value of resistances is based upon the resistance of the single 1 in. cylinder, as before so the values are directly comparable.

Test (b) is shown as only one point on Fig. 3, giving a value of 45 per cent of the resistance for the single cylinder. A slight improvement over the 1:1 combination.

Discussion of Results

An examination of Fig. 4 gives us the clearest conception of the investigation. Consider first the three ratios 1:¾, 1:2-3, 1:½, the curves of all have the same character, crossing and recrossing each other several times. The general trend is, in each case, a slight decrease in resistance between the spacing of 1 and 2 diameters to an average of 80 per cent of the resistance of a single wire, then a gradual increase in resistance as the spacing is progressively lengthened to 3½ or 4 diameters where the two wires have about 130 per cent of the resistance of a single wire. About 4 diameters the rate of increase drops off so that there is little advantage or disadvantage between 4 and 8 diameters spacing.

The 1:1 ratio has an individual curve from 1 to 3 diameters. It does not, however, contradict our expectation from the other three cases, since it may readily be seen from the 1 diameter



spacing of each that the resistance is progressively lowered as the ratio approaches unity, as

1 : ½ = 70 per cent of single cylinder
1 : ⅔ = 83 " " "
1 : ¾ = 72 " " "
1 : 1 = 40 " " "

From 3 to 4 diameters the curve is coincident with the other three, and above 4 diameters rises a little more steeply, as anticipated, towards 200 per cent, which should be its ultimate. The curve for the filled in gaps tests is self-explanatory.

Conclusions

The 1:1 ratio, as generally employed by manufactories today in the wing wire bracing, gives appreciably less resistance than the other three combinations for spacing less than 3 diameters, and only a small per cent more at greater spacing. In practice, it would be necessary to maintain the same wire strength, necessitating a larger front wire than used in the 1:1 ratio—thus a larger unit resistant—with the probable loss of any slight advantage anticipated from the tapering combinations.

In practice, no material advantage is to be gained where tandem wires are employed by making the rear wire of a smaller diameter than the front one.

The present practice and spacing of two wires in tandem gives a resistance of approximately one and a half that of a single wire.

The resistance of any combination is greatly reduced by filling in the gap betweeen the cylinders, especially where the space is greater than four diameters.

When wires are wrapped the spacing is of no importance.

Tapering the wrapped wire is of no material advantage.

Recommendations

(1) The usual practice of using wires of equal diameter where two wires are employed should be adhered to, as it is the best, both from resistance and strength considerations.

(2) Unless the space between the wires is less than 2 diameters, the gap between them should be filled. Two-thirds of the resistance is thus saved.

As an illustration of the advantage to be gained by filling in the wire gap, the following calculation for a typical biplane has been included: wing wires arranged as usual; double flying wires, single landing wires, diameter, $\frac{3}{16}$ in.; total length, 360 ft.; length exposed to wind, 120 ft. of single wire; 120 ft. of double wire; spacing 6 diameters, $1\frac{1}{8}$ in. Resistance of wires at high speed, 75 m.p.h. Resistance $\frac{3}{16}$ single wire at 75 m.p.h. = 225 lbs./ft. run.

From Fig. 4, resistance of double wire uncovered, 6 diameter spacing, equals 145 per cent of single wire. Therefore, resistance double wire = $.225 \times 1.45 \times 120 = 44$ lb. Resistance of single wire = $.225 \times 120 = 31$ lb. Total resistance = 75 lb.

When gap on double wire as filled in resistance is only 53 per cent. of single wire. Double wire resistance = $.255 \times .53 \times 120 = 16$ lb. Total resistance = 47 lb.

Using double wires of equivalent strength for landing wires in place of single $\frac{3}{16}$ and filling in the gap, we have an additional saving.

Using two ⅛ in. wires, resistance at 75 m.p.h. = .160 lb. per foot run. Resistance double wire, 6 diameter spacing filled in gap 53 per cent single wire = $.160 \times .53 \times 120 = 10$. From above flying wire resistance = 16 lb.

Total resistance with both flying and landing wire gaps filled = $16 + 10 = 26$ lb. Saving over original: $75 - 26 = 49$ lb.

Horsepower saved by filling in wire gaps in wing trussing $= \frac{T \times \text{velocity (ft. per run)}}{550} = \frac{49 \times 110}{550} = 10$ H.P.

Aeronautical Patents

Copies of these patents may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."

ISSUED MAY 15, 1917.

1,226,312. Filed December 31, 1915. To George W. Cline, Albany, Ore. Stabilizer for flying machines.

1,226,521. Filed February 25, 1914. To John M. Huff, San Francisco, Cal. Flying machines.

1,226,599. Filed November 7, 1916. To William Frederic Saunt, Lundy Island, North Devon, England. Aerial Machine.

ISSUED MAY 22, 1917.

1,226,985. Filed September 20, 1905. To George Francis Myers, Columbus, Ohio. Flying machine.

1,227,200. Filed June 17, 1916. To Harry E. Rose, Spokane, Wash. Propelling device.

1,227,269. Filed July 12, 1916. To Chas. M. Hunsicker, Dayton, Ohio. Flying machine.

Book Review

GASOLINE AND HOW TO USE IT

By G. A. Burrell (Oil Statistical Society, Inc., Boston). Pp. 281. Price $1.50

This little book is a mine of valuable information on the subject of gasoline. It deals with every possible aspect of the subject in a concentrated but authoritative manner.

In some of the earlier sections of the book, attention is given to the danger arising from the inflammability of the product. Carbon tetrachloride, the basis of various chemical fire extinguishers, is recommended as one defensive method. Excellent methods of first aid treatment for gasoline burns are described.

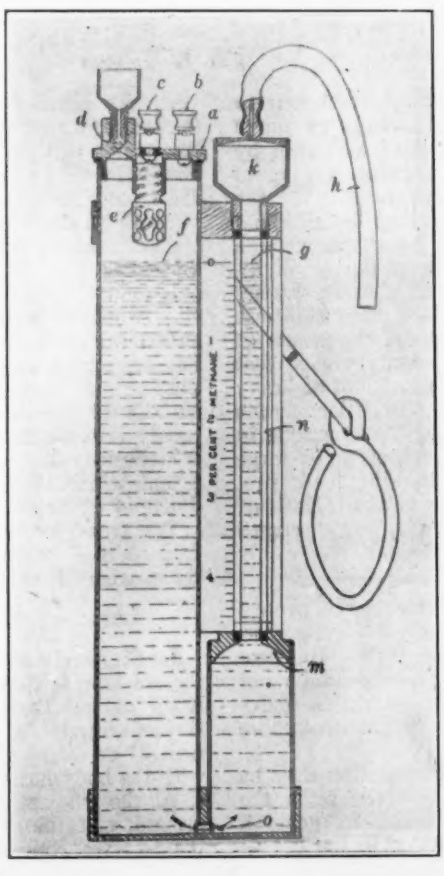
The author, it appears, is an inventor of a very interesting apparatus for detecting gasoline vapor, shown in the diagram, of which the following description is given:

The instrument may be considered to be a U-tube, of which the limbs (S) and (N) are two branches. Communication is made between the two limbs at a point designated by the arrow.

To start a series of determinations the brass cap (A) is removed and water is poured into (F) until it rests in the tube (N) at the point (G), the zero point of the scale. The water will then seek the level (F) in the tube (S).

To make a determination of combustible gas in air, say of gasoline vapor in air, one blows in the tube (H) by means of a rubber tube (not shown), thereby depressing the water in (M) to some point and filling the combustion space above (F) with water. One can tell when this combustion space is filled with water by hearing a slight click when the water strikes the valve (D). Next, the instrument is raised to the place where the sample is to be collected and the water allowed to seek the former levels at (F) and (G). The water in falling to (F) sucks in a sample of the air to be tested. Next the valve (D) is closed and the platinum wire in (E) electrically heated. The gasoline in the combustion chamber burns to carbon dioxide and water, and the contraction in volume of the sample occurs corresponding to the amount of gasoline originally present in the sample. At the end of one and one-half minutes the electric current is turned off and the instrument shaken to cool the gases in the combustion space and bring them to the same temperature as the gases were at the beginning of the test. The water in the combustion space will then rise to take the place of the burned-out gas and fall a corresponding distance in the glass tube (N), i. e., fall to a point on the graduated scale that will show the percent of gasoline originally in the sample. A previous calibration, once and for all time, fixes the proper four graduations on this scale. The latter carries four graduation columns, one for methane and natural gas, one for hydrogen, one for gasoline vapor and one for coal gas.

The electrical energy for heating the platinum wire is derived from a storage battery. A test requires two minutes.



The mysterious disease "petromortis" is traced to its proper cause—the presence of carbon monoxide in the exhaust. The author states that the chances of the deadly carbon monoxide occurring in the exhaust gases are very great. The production of carbon monoxide is rightly attributed to too rich a mixture with the resultant incomplete combustion.

A whole set of pointers are given on gasoline in connection with engine trouble. These are well known, but are usefully summarized and collected.

A good set of pointers are also given for lubricating oils together with a number of tests for these oils, such as heat test, flash test, fire test, specific gravity test, viscosity test, carbon residue test and service tests.

The latter part of the book deals with the composition of petroleum from various parts of the United States, and figures for a number of comparative tests.

Course in Aerodynamics and Airplane Design

By Alexander Klemin, A.C.G.I., B.Sc., S.M.

Instructor in Aeronautics Massachusetts Institute of Technology, Member of the Aeronautical Society of Great Britain and Ireland,

and

T. H. Huff, S.B.

Instructor in Aeronautics, Massachusetts Institute of Technology

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PART II—SECTION 8

General Principles of Chassis Design

The design of landing gears is among the most complex of the problems which confront the aeronautical engineer, due to the many conflicting factors which must be taken into consideration and, so far as possible, reconciled.

General Proportions

The height of the chassis is dictated by the necessity of providing ground clearance for the propeller and by the angle of attack which is desired in starting and in pulling up after touching the ground. The track must be sufficient to insure against overturning when making a landing on rough ground, yet not so great that the striking of a soft spot by one wheel will give rise to an excessive moment tending to spin the machine around. The fore-and-aft location of the wheels is determined by the requirements of longitudinal stability on landing. The structure must be strong enough to withstand side thrusts and twisting moments due to alighting on one wheel, as well as the large direct dyamic stresses which are set up when an airplane lands without sufficient flattening out of the angle of descent. Lastly, the means of shock absorption must be of such quality and number that they will permit of high speed along the ground and of heavy landings without breakage of the shock absorption means itself and without danger of the "bottoming" of the axle in its guides. The play of the absorbers should also be large enough so that the dynamic landing and taxi-ing loads previously alluded to will not reach excessive values. Each of these conditions will now be taken up in turn, and discussed in detail.

Chassis Height

Ordinarily, the most important factor here is the protection of the propeller. With a conventional shock absorber, allowing a total displacement of five or six inches, the propeller clearance with the machine stationary should be not less than twelve inches, thereby insuring a minimum clearance of six inches when the shock absorber has its maximum displacement.

Under some circumstances, the governing condition may be the angle of incidence to which it is desired to pitch the machine. The greatest possible angle should, in general, be at least as great as that which corresponds to the burble point, and it may be advisable, if a very short run after landing is required and brakes are not desired, to make it somewhat larger than this. The following example will illustrate the use of this condition:

A two-seat tractor biplane is 26 feet long, and the horizontal distance between the axle and the point of contact of the tail skid is 20 feet. In normal flight, when the line of thrust is horizontal, the wings are set at an angle of incidence of 4 deg., and the point of contact of the tail skid is 2 ft.

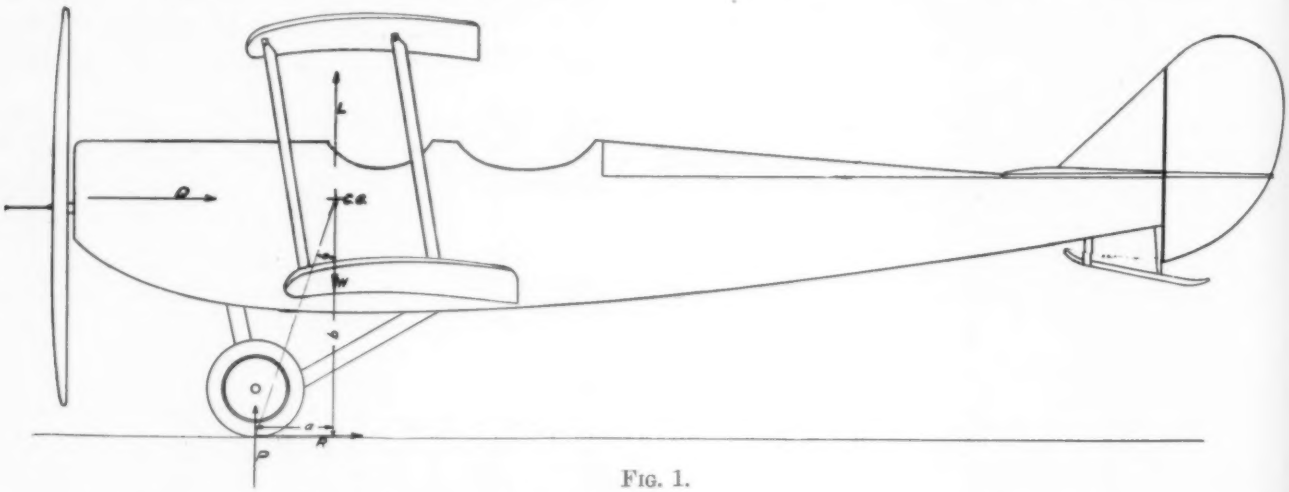

FIG. 1.

vertically below the line of thrust. It is desired to find the least distance of the lower rim of the tire below the thrust line which will permit the assumption of an angle of 18 deg. Since the wings are at an angle of 4 deg. in normal flight, the maximum angle between the thrust line and the ground must be 18 deg.—4 deg., or 14 deg. Tan 14 deg. = .249, and the difference in heights of the wheels and tail skid is therefore $20 \times .249$, or 4.98 ft. It is then evident that the required height is $4.98 + 2$, or virtually 7 ft., a much greater height than would be necessitated by propeller clearance alone. If such large angles must be attained it is worth while to sacrifice something from the perfect symmetry of the body by putting most of the longitudinal curvature on the lower surface of the body, thereby bringing the tail skid more nearly into the line of thrust and decreasing the height, and consequently the weight and resistance, of the body, to an extent which more than compensates for any loss of aerodynamic efficiency of the body.

The tread, or track, is, on airplanes of conventional size, from 5 to 7 ft., except on slow pusher biplanes with long skids, where it may reach values as high as 13 ft.

Location of Chassis with Respect to C. G.

In Fig. 1 are shown the forces which come into play while the machine is running along the ground. It is evident that, if we assume the thrust line to pass through the c. g., and the machine to be in equilibrium with the elevator either in neutral or diving position, so that the resultant air pressure with the body horizontal passes through or slightly behind the c. g., the moment $P \times a$, due to the upward reaction of the ground, must be at least equal to the moment $R \times b$, due to the tractive resistance. We then have since we may write

$R = \gamma P$, $P \times a = > \gamma P \times b$, or $\frac{a}{b} = \tan \theta = \gamma$, where γ is the coefficient of tractive resistance. If we assume $\gamma = 1/10$, which is perhaps a fair value for a vehicle with large and flabby pneumatic tires running over smooth grass, we have $\theta = 5$ deg. 44 min. Since, however, it is necessary to allow for soft ground, where the coefficient of tractive resistance will be much increased, as well as for ruts and changes of slope, which introduce a backward component in P itself, it is obvious that θ will have to be considerably larger than the value given above. Capt. B. Q. Jones, U. S. A., states that the best practise indicates a value of 13 deg. 10 min. for θ.

Stresses and Structural Considerations

An unequal distribution of stress between the wheels, due to landing on one wheel before the other or to a difference in ground conditions between the two tracks, produces a moment tending to twist the axle about a vertical axis. This moment

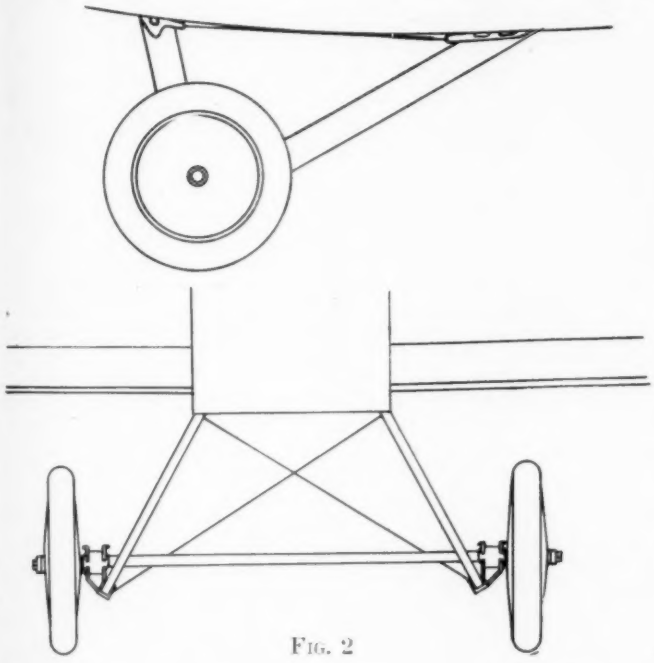

FIG. 2

is carried to the struts or skids by means of axle guides or radius rods, and thence to the body. A landing on one wheel generally involves a sideways motion, and the resulting sideways blow is usually carried by the cross-wires, although some landing gears, particularly on speed scouts, have inclined struts which, acting either in tension or compression, take the place of the wires in this respect. In order to resist side blows, too, a special wheel construction is necessary, as an ordinary wire wheel, such as is used on motorcycles, will be completely wrecked by a relatively small side blow against the rim. It may be laid down as a rule that the length of hub should be at least twice the diameter of the tire, and three times is preferable. The obliquity of the spokes is thus greatly increased.

Direct dynamic loads in landing have already been discussed in this course (see AVIATION AND AERONAUTICAL ENGINEERING, May 1, 1917). The table there given is somewhat in error, although the method of derivation is correct. The following are the correct values:

Displacement of shock absorbers.	Maximum force in chassis.
1 in.	35.0 W
2 in.	19.0 W
3 in.	13.0 W
4 in.	10.3 W
5 in.	8.6 W
6 in.	7.5 W
8 in.	6.1 W
10 in.	5.3 W
12 in.	4.8 W

The formula should be: $F = W\left(2 + \frac{2.77}{x}\right)$, instead of $W\left(2 + \frac{5.7}{x}\right)$.

The encountering of bumps and ruts while running along the ground may also give rise to very high stresses, but they are never likely to be so great as those resulting from a landing at the natural angle of glide, or from a pancake landing involving a sheer drop from a height of 1 ft.

Shock Absorbers

Rubber and steel springs are the only substances which have been widely used as shock absorbers. Of these, rubber has proved by far the more satisfactory, due to its easy fabrication and replacement, its greater energy-storing capacity (500 to 1,000 ft. lbs. per lb., as against 10 to 20 ft. lbs. per lb. for steel), and, most of all, the fact that it actually absorbs and dissipates the energy, instead of merely storing it and giving it out again. If steel springs are used, some auxiliary device must be employed to dissipate the energy in the form of heat. In the case of leaf springs, this is done in a fairly satisfactory degree by friction between the leaves, and such springs have been used on light machines built for smooth fields, but they do not afford sufficient give for heavy work. Where helical springs are used, as on many large pusher biplanes with four-wheeled landing gears, they are usually in combination with a hydraulic or pneumatic shock absorber. As an illustrative problem, we shall give the complete calculation of a rubber shock absorber for a two-seator tractor biplane weighing 2000 lbs., having a gliding angle of 1 in 7, and a speed range of from 45 to 90 miles an hour. We shall start with the assumption that the heaviest landing shock which needs to be provided against is that due to landing at 45 m.p.h. on a slope of 1 in 6 without any attempt at flattening out.

The shock absorbers will be made up of rubber rings 2 in. in diameter, and 2 in $\times$ $\frac{5}{16}$ in. in section. We shall use a two-wheeled landing gear, so that each wheel will have an initial load of 1000 lbs. The initial stretch will then be $\frac{1000\ l.}{E \times A \times n}$. E, the modulus of elasticity, may be taken equal to 300 lbs. per sq. in. for rubber of good quality. A, the total cross-section area of one ring, is $2 \times 2 \times \frac{5}{16}$, or $1\frac{1}{4}$ sq. in. l, the length, may be taken equal to one-half the perimeter of the rings, or $l = \frac{2 \times \pi}{2} = 3.14$ sq. ins. n is the number of rings employed.

We then have $S = \frac{1000 \times 3.14}{300 \times 1\frac{1}{4} \times n} = \frac{8.39}{n}$, and s, the deflection under any load, $= \frac{16.78F}{Wn}$, F being the total load.

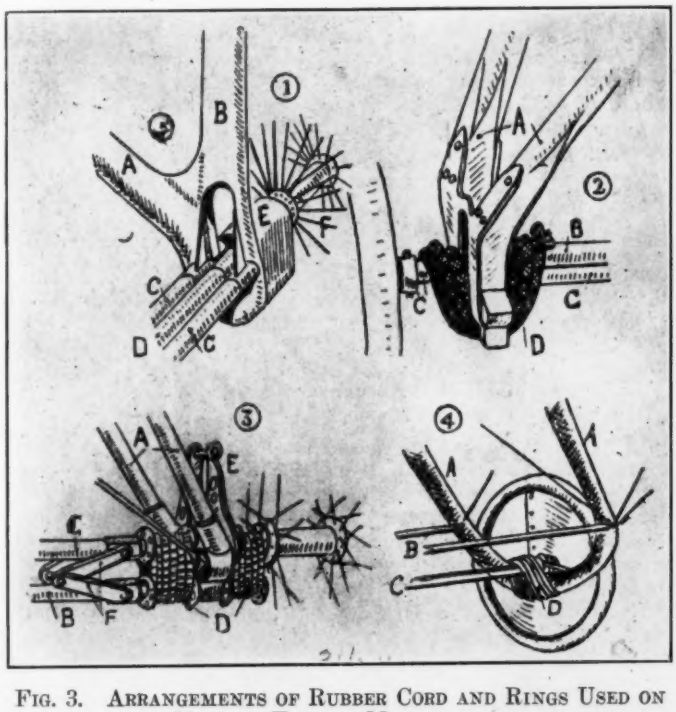

FIG. 3. ARRANGEMENTS OF RUBBER CORD AND RINGS USED ON VARIOUS FRENCH MONOPLANES.

On landing on a slope of 1 in 6 at a speed of 66 ft. per sec., the vertical speed is 11ft. per sec., and the kinetic energy is $\frac{(11)^2 \times W}{2g}$, or $1.88W$ ft. lbs. The potential energy possessed on touching the ground is $\frac{WS}{12}$, making a total of $W\left(1.88 + \frac{s}{12}\right)$, or $W\left(.94 + \frac{s}{24}\right)$ on each wheel.

The energy absorbed by the shock absorber is $\frac{F}{2} \times \frac{s}{12} = \frac{Wns^2}{402.7}$. Equating this to the energy possesed by the machine, $\frac{Wns^2}{402.7} = W\left(.94 + \frac{s}{24}\right)$. We shall assume a deflection of 5 in. Then $n = \frac{402.7\,(.94 + 5/24)}{25} = 18.54$. We shall use 18 rings and recalculate. Then $\frac{18\,s^2}{402.7} = .94 + \frac{s}{24}$, and $18\,s^2 = 378 + 16.78\,s = 5.05$ in.

The stress in the rubber is $\frac{5.05}{\pi} \times 300 = 482$ lb. per sq. in., as against a breaking strength of 800 lbs. per sq. in., and the load on the chassis $= \frac{2W\left(1.88 + \frac{s}{12}\right)}{\frac{s}{12}} = \frac{4000 \times 2.30}{.42} =$ 21,900 lbs. At the instant of greatest displacement, then, every part of the machine has on it a downward load of eleven times its own weight.

We have so far assumed the most unfavorable condition with respect to the tires: that is, that they do not deflect at all. We shall now work the same problem on the assumption of the most favorable conditions reasonably to be expected, that 26 × 4 tires are used, and that they are pumped to such pressure that they collapse 2 in. under the same force which causes the shock absorbers to yield 5 in. The effect of this is equivalent to increasing the length of the shock absorbers by 40 per cent. We then have $F = \frac{Wns}{23.49}$, and $\frac{Wns^3}{563.8} = W\,(.94 + \frac{s}{24})$. s now equals 7 in., and n is therefore $\frac{563.8\,(.94 + \frac{7}{24})}{49}) = 14.28$. Only 14 rings will be needed under this assumption.

Actually, a 2500-lb. airplane usually employs about 12 rings on each bridge, and is therefore unable to sustain conditions as severe as those which we have assumed. In order to provide the desired shock absorption capacity, machines of the size which we are considering use 26 × 4 or 26 × 5 wheels. These wheels weigh, complete with tire, from 17 to 25 lbs. each, and the manufacturers recommend that they be pumped to 60 lb. pressure.

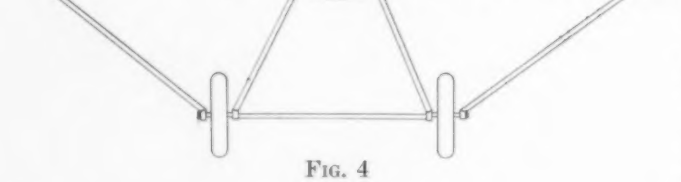

FIG. 4

In place of rubber rings, as specified above, rubber cord woven from many strands may be used. Some recent tests on ⅝ in. cord, made up of 180 strands $\frac{1}{32}$ in. square, showed a modulus of elasticity of 434 lb. per sq. in. The breaking load was not determined. During these tests, it was discovered that the "permanent" set which rubber cord takes after being stretched, 40 per cent of its original length almost entirely disappears after 17 hours of rest, the rubber regaining all its original properties.

Types of Chassis

We may, in general, divide chassis into three classes: self-contained chassis with wheels alone, chassis with two principal wheels and a tail skid, and chassis built up around one or two long skids as a basis. There are also numerous compromise designs, which it is difficult to assign to any one class. Nearly all the land machines now built in the United States come into the second of these classes, although all three types had some vogue here at one time.

Chassis with wheels alone were first used by Curtiss. Due to their complexity and considerable weight and resistance, they are now seldom employed except on heavy machines, particularly pusher biplanes designed for gun-carrying, where

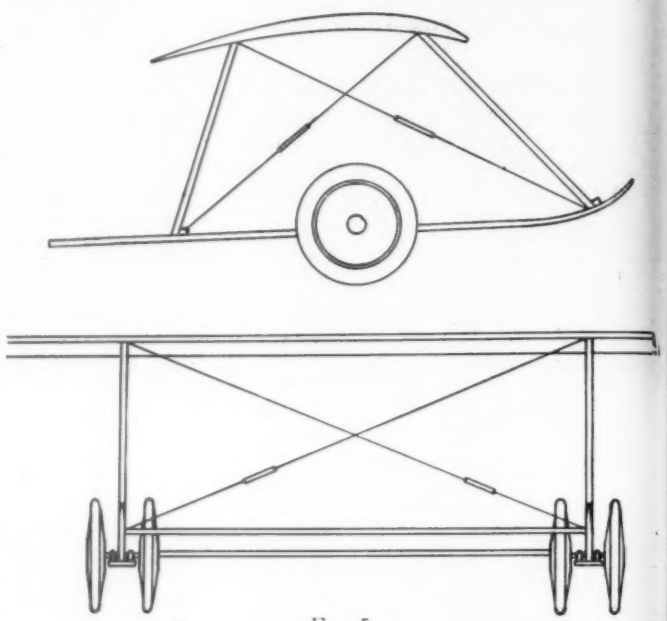

FIG. 5

they are generally combined with selical steel springs and hydraulic shock absorbers. Such a chassis may have either three or four wheels, four being the more common. The fore-and-aft distance between the two pairs of wheels must be considerable, in order to insure against the machines falling over on its tail as it is brought to rest.

Chassis with two principal wheels and a tail skid, either with or without one or two subsidiary, and usually unsprung, wheels in front, are nearly universally employed on machines of medium and light weight, except on the very slow and lightly-loaded pusher biplanes. The framework of such a landing gear is reduced to its lowest terms, consisting, in its conventional form, merely of two Vs, closed at the top by the lower body longerons, and separated at the top by a distance equal to the width of the body, and at their lower vertices by a little less than the track of the wheels. The bottoms of the Vs are connected by a strut. The two wheels are mounted just outside the Vs, either on a single axle or on separate axles hinged at the center, usually the former. The present practice is to incline the axle guides so that the wheels travel backward somewhat as they rise in the guide slots, but this causes excessive wear on the front of the slots, and experiments at the Signal Corps school indicate that no harmful results follow the elimination of the backward slope. Fig. 2 gives a diagrammatic view of a typical chassis of this class.

On speed scouts, where the reduction of resistance is of the utmost importance, the chassis is sometimes so built that it forms a unit with the wings. This makes possible the elimination of all wiring from the chassis, and in a few cases from the wing panel as well. Fig. 4 represents a machine so braced.

Chassis based on long skids are used on Farman, Caudron, and Wright biplanes. They generally embody four comparatively small and light wheels arranged in a straight line, one pair of wheels, about 18 inches apart, being attached to each skid. Each pair of wheels has its own axle, and radius rods are used to prevent the axle twisting with respect to the skid. Rubber shock absorbers are used. In some cases the skids are carried up in front to a forward elevator, as in the Maurice Farman, or in the rear to the tail, as in the Caudron. Such a chassis is illustrated in Fig. 5.

Among the hybrid types, involving some of the features of all three classes, one of the most interesting is the old Nieuport.

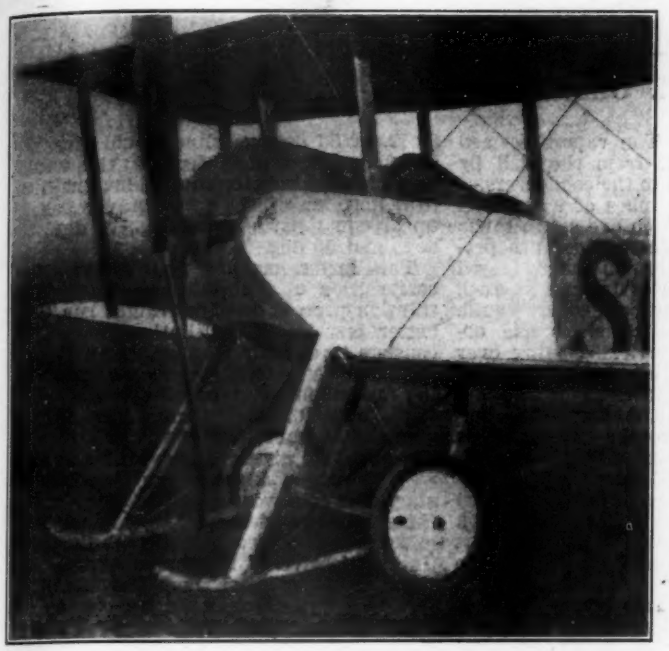

FIG. 6. SOPWITH CHASSIS, SHOWING COMBINATION OF TWO WHEELS WITH SHORT SKIDS

In this there were 2 pairs of struts, each pair forming a V with the vortex downward. At the bottom of these was mounted a comparatively short skid. Below the skid a leaf spring, of semi-elliptic form, was clamped, and the wheels were at the extremities of this spring. The rear of the skid acted as a tail skid, and, in addition, made a very effective brake, as it was close to the c. g., and consequently carried a considerable portion of the weight.

Brakes and Braking

All the devices which have been brought forward for checking the speed of airplanes after touching the ground fall naturally into one of two divisions: depending either on air resistance or ground resistance. The best example of a brake depending on air resistance is the airplane itself. We have already mentioned the desirability of being able to depress the tail to such a degree as to secure a very large angle of incidence, not only so that we may land at low speed, but also so that the drag may be increased, and thus aid in checking the speed after landing.

It has often been proposed that air brakes, consisting of surfaces normally lying parallel to the line of flight, but capable of being pulled around approximately normal to that line, should be provided. If two such surfaces, one on either side of the body and at a considerable distance from the longitudinal axis, are furnished, one at a time may be pulled out to act as a drag and assist in turning the machine in a small circle while taxi-ing, or both may be used at once as a brake. The trouble with all air brakes is that they rapidly lose their effectiveness as the airplane begins to slow up. They have, on the other hand, the advantage that their force is exerted well above the c. g., so that there is no tendency to stand the machine on its nose.

Brakes depending either directly or indirectly on friction, with the ground for their retarding power, may be subdivided into wheel brakes and sprag or claw brakes. Wheel brakes, although they can be made very powerful, are hardly ever used, due to their danger, which lies in the difficulty in releasing them quickly, and in the fact that they have no tendency to release themselves automatically as the machine starts to pitch over on its nose.

Claw brakes are more used than any other type. They are usually attached to the strut, which lies just below the axle in a V-type landing gear, and are hinged to that strut. The claw on the end can be brought to bear against the ground by a lever within reach of the pilot. The advantage of such a brake is that, being in back of the forward point of suspension, the claw tends to release itself as the machine starts to dive, pivoting about the point of contact of the wheels with the ground. From this point of view, the brake should be as far back as possible, but the available retarding force is greater and the construction is simpler when it is kept near the chassis proper. The tail skid itself acts as a very efficient claw brake if it is so arranged as to carry a considerable portion of the load. If extra quick stops are desired from a machine, whatever type of brake is used, the wheels should be placed farther forward of the c. g. than usual, thus permitting a larger moment to be applied at the ground level without upsetting the machine, making it easier to get the tail skid down in contact with the ground immediately after landing, and throwing a larger portion of the weight on the tail skid or sprag brake, if one is used.

It is of interest to determine the retarding force required to bring a machine to rest in a given distance. If, for example, we wish to land a 2500-lb. machine at 45 m.p.h. and bring it to rest in 200 ft. after touching the ground, we have $s = \frac{v^2}{2a}$, or $a = \frac{(66)^2}{600} = 7.26$ ft. per sec. where a is the necessary deceleration. F, the average retarding force, $= \frac{W \times a}{g} =$ 565 lb., a force which might easily be secured without the use of any brake save that afforded by the wings themselves.

REFERENCES FOR PART 2, SECTION 8.

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"L'Essor et l'Atterissage," by Maurice Percheron.
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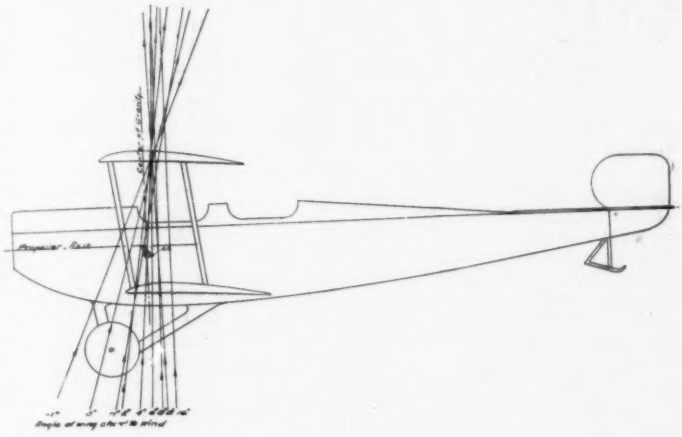
"Notes on Aeroplane Shock Absorbers of Rubber," by J. C. Hunsaker; AVIATION AND AERONAUTICAL ENGINEERING, Sept. 1, 1916.

Erratum Note

In the table of data for airplane engines, published in AVIATION AND AERONAUTICAL ENGINEERING for April 1, 1917, the rated horsepower of the Curtiss OX-2 engine was given as 85 instead of 90, which is the correct value. This should be altered in the table.

NOTE—The vector diagram for the JN-2, to which reference was made in discussing the design of a secondary training airplane in the last installment of the course, is reproduced herewith. The weights are omitted in order not to confuse the diagram, but the position of the c. g. is that indicated previously.



THE EQUIVALENT MASS IN RIGID DYNAMICS, WITH APPLICATIONS TO GYROSCOPES AND SCREW PROPELLERS

By A. F. Zahm. *Journal of the Franklin Institute.* 183 pp. 207-210.

In the analysis of the motion of a rigid body, it is often convenient to substitute a mass-equivalent for the actual body. With a plane distribution of mass, the system reduces to four particles, and with linear distribution, to two.

As an example, a gyroscope is considered in which steady rotation occurs about two axes. The fact is brought out that the torque about the centroid is independent of the acceleration or speed of the same. The principle is applied to determine the gyroscopic action of a standard Curtiss two-blade propeller, showing that the resultant of the three component torques is only one-eightieth of one per cent greater than the major one. The equivalent of such a propeller operating under normal conditions may therefore be considered as a two point system.

Gasoline

By Augustus H. Gill, Ph.D.

Gasoline is the term applied to the lighter portions usually obtained by distilling crude petroleum. It was originally given to the distillate lighter than 80 deg. (0.666 sp.gr.) on the Baumé scale. This particular variety was seldom used for power production. Of late, however, the demand for gasoline has become so great that almost anything lighter than ordinary kerosene, 45 deg. Baumé is used, as "V. M. & P. naphtha," (varnish maker's, and painter's naphtha) 57 deg. Bé gravity, a substitute for turpentine, 62 deg. Bé or "stove naphtha," the present motor gasoline, whereas 70-76 deg. Bé naphtha, the old motor gasoline, is scarcely obtainable. The terms gasoline and naphtha are now used interchangeably and apply to all the products of petroleum lighter than kerosene.

Gasoline is not a homogeneous liquid like water or alcohol, but a mixture like water and denatured alcohol. That is to say, as in the latter mixture we have water, grain alcohol, wood alcohol, and, in some cases, gasoline, so in the case of gasoline, we have a mixture of clear, colorless and volatile liquids known to chemists as the paraffin hydrocarbons—called decane, nonane, octane, heptane, hexane, pentane and others. These are mingled in various proportions according to the crude product and method of distilling. Decane ($C_{10}H_{22}$) is the heaviest and pentane (C_5H_{12}) the lightest of these and as they may be mixed in any proportion it is easy to see why gasoline can vary so widely and yet be true to name.

Gasoline is designated by certain numbers as "Gasoline 86 deg.," "Gasoline 62 deg." This refers to its density, gravity or weight. These numbers have no connection either with its percentage composition, as in the case of alcohol, flashing point, or boiling point, but refer simply to the Baumé scale for liquids lighter than water. A weighted glass spindle—a hydrometer as it is called—sinks to the 86th division in one case, and the 62nd in the other, the liquid being at a temperature of 60 deg. Fahr.: in water, the instrument sinks to the 10th division. That is the less the liquid weighs, or the lighter it is, the greater is the number on the Baumé scale: our 86 deg. gasoline weighs 5.4 lb. per gallon, having a specific gravity of 0.648 whereas the 62 deg. naphtha weighs 6.07 lb. and has a specific gravity of 0.729.

Gasoline varies according to the source of the crude oil from which it is prepared: in the eastern and Ohio fields it is of lighter gravity and consequently volatilizes more rapidly than from far western or Gulf fields, and in the Middle West it is a mixture of the two. This is due to the fact that the chemical constitution of the eastern gasoline which is chiefly light paraffin hydrocarbons is different from that of the Gulf gasoline which is mainly the heavier asphaltic hydrocarbons.

How Gasoline Is Obtained

Gasoline is obtained in three different ways:

1. By distilling crude petroleum.
2. By "cracking" the heavier distillates from petroleum.
3. By cooling or washing natural gas or "casing head" gas.

In the first process, crude petroleum is pumped into a horizontal still 42 ft. long by 15 ft. in diameter, holding 1200 barrels (50400 galls.) resembling a horizontal tubular boiler without the tubes. This is heated either at the end or side, using coal or oil as fuel. The vapors formed by the heat pass out from the still by domes and goosenecks to the condensers,—coils of pipe like the tubes of a Babcock and Wilcox boiler, which are set in tanks of running water. These pipes are provided with traps to allow the uncondensed gas to escape—which is burned as fuel. The vapors are condensed to a liquid. Products of different densities are obtained, the lighter portions coming over first, the different portions being separated according to the indications of the hydrometer. These are treated with sulphuric acid to remove the "skunks," as the bad smelling portions are called, washed with alkali and water and redistilled: the lighter portions are usually called gasolines, and the heavier, naphthas. If a gasoline be obtained which is too heavy, it can be made lighter by adding some of the earlier distillates: thus gasoline 76 deg. might either be a straight distillate or be a mixture of the first or light portions with the later or heavy portions. This is inferior to the other as it does not vaporize so readily and the composition of the vapor is not uniform.

By "Cracking"

This consists in decomposing the heavier oils like mineral sperm, into lighter products and gas. This is carried out by cooling the top of the still rapidly after the kerosene distillate has come off. The heavy vapors from the hot oil rise, strike against the cold top of the still, condense and drop back into the hot liquid in the still where they undergo decomposition into gasoline. This is condensed and treated as has been described. The Rittman, Burton and other processes are all based upon this principle and use pressure as well as heat to bring about the decomposition.

From Natural Gas

Natural gas contains besides methane, its chief constituent, appreciable quantities of the vapors of heavier hydrocarbons of the methane series (homologues, as the chemist says). These are chiefly the hydrocarbons from pentane to decane already mentioned: besides these, it also contains the lighter ones as ethane, propane and butane. The quantity of gasoline that a natural gas contains varies from 0.1 to 13 gallons per thousand cubic feet.

The gas is compressed at pressures varying from 80 to 275 lb. cooled and run into storage tanks. According to the amount of compression, from 72 deg. to 100 deg. Bé gasoline can be obtained. Or the gas is made to pass up through towers filled with stones over which an oil trickles. The oil used is obtained after the kerosene distillate and is known as mineral "seal" or "sperm" or "300 deg. fire test oil." This oil after having been treated with the natural gas, goes to a steam still where the gasoline absorbed is distilled off from it, and condensed as in the other two processes already described.

Tests for Gasoline

The test most commonly employed is that of the gravity (degrees Baumé), already mentioned. It is of little value, as the gravity of a mixed or blended gasoline can be made the same as of a "straight run" or distilled product. The former is the less desirable, as in use or upon standing it rapidly loses the volatile part, making an engine run irregularly. For example, 50 lb. of 86 deg. and 50 lb. of 56 deg. gasoline would give 100 lb. of a mixture of 71 deg. Bé: this would be somewhat inferior in working qualities to a gasoline of the same gravity, made up of equal parts of 86 deg., 76 deg., 66 deg., and 56 deg.

This latter gasoline approximates the composition of that obtained in the distillation process or of "straight run." A better test is the distillation test. This consists in distilling 100 cc. in an Engler flask connected with a condenser and noting the volumes coming off below 100 deg. Cent. and 165 deg. Cent. The former quantity is a measure of the volatility of the gasoline, giving an idea of the ease with which a motor using it could be started in cold weather. The latter shows the extent to which a very heavy naphtha or kerosene has been mixed with the gasoline, indicative of a blended article. In the case of the latter the test would show a very considerable quantity coming off below 100 deg. Cent. and at about 165 deg. Cent. with a scanty volume in between. With a "straight run" the distillate increases in a fairly regular order.

The following table shows the composition of some gasolines recently obtained. The first two are "aviation gasolines" of asphaltic base, and the last two "automobile gasolines."

Designation ..	70 deg., Bé	60 deg.	No.1	No.2
Gravity deg., Bé.....	62.5	59.8	61.2	61.4
Distillation test				
Percent below 100 deg. Cent.....	30	34	29	41
Percent below 165 deg. Cent.....	85.5	89	88	91.5

The last one is a well-known brand, and is clearly the best for all purposes as shown by the high percentages below 100 deg. Cent. and 165 deg. Cent.

While it is difficult, with a decreasing supply, to adhere to specifications, it is suggested that gasoline for aviation purposes should be a straight run product, containing at least 40 per cent boiling below 100 deg. Cent. and 90 per cent boiling below 165 deg. Cent.

Properties

Gasoline ignites at 1,400 deg. Fahr.—a dull red heat. It cannot be ignited by a soldering copper, a cigar or cigarette—but woe to the man who uses a blow torch, or lights his cigar with a match, in the proximity of gasoline vapor; the temperature of these flames is about 2100 deg. Fahr., very much above the ignition point of gasoline.

While it is ignited in use by a voltaic or dynamic spark, the point must not be overlooked that it can also be fired by frictional electricity. Some of the common and queer ways of this ignition are as follows: One of the earliest of these was the "hair dresser's accident," in 1897. A woman was being shampooed with a wash containing gasoline, sufficient frictional electricity was generated to produce a spark which ignited the vapor, burning her so severely that she died. A naval surgeon wearing rubber boots (which insulated him) and a fur coat, made a spark, presumably by the friction on the fur, sufficient to ignite the gasoline in the tank of the automobile and burn him and the car severely. (Wearers of fur coats not infrequently generate sparks of considerable intensity.) Gasoline is electrified by passing through chamois skin or a rubber hose. Automobiles have been set on fire when the chamois-lined funnel used in filling the tank, and perhaps insulated from it by a wooden block, has been removed, mak-

ing a spark. A similar case exists with the hose through which the gasoline is pumped: here the cock on the end did not touch the tank, and when taken away, a spark jumped between them, firing the gasoline. The chamois should be replaced by 80-100 mesh brass gauze and the hose should carry a chain or wire connecting it and the end cock with the metal pipe at the storage tank.

Handling Gasoline

In filling 5-gal. cans, for example, they should be connected with the gasoline pump by a chain or wire, as the wooden handle on the bail insulates it. The friction of the gasoline in the pipes makes electricity enough to cause a spark to jump from the pump to the can, firing the gasoline.

In handling gasoline, it should be remembered that the vapor is heavier than air—three and one half times—and settles. It flows like a river, and has been known to run in a stream or stratum and ignite from a boiler fire sixty feet away. When ignited it strikes back to the source whence it came.

Gasoline does not explode unless it burns in a confined space: the explosive ranges, that is, the volumes necessary to make air explosive, are between 1.5 and 6. That is, a mixture containing one and one-half volumes of the vapor, and any proportion thereof up to six volumes of the vapor is explosive. Putting it in another way, two quarts of gasoline is diffused through a room 10 x 10 x 10 feet, would make a first rate explosion. This is equal to about five tablespoonfuls in a 5-gal. can.

The heating value of gasoline varies from about 17,860 for 62 deg. Bé to about 18,080 for 76 deg. Bé, B.t.u. per pound, or 109,024 and 102,152 B.t.u. per gallon respectively: that is, the heavier gasoline has the greater heating value per *gallon* and less per *pound*.

Insurance for Aviators*

The National Advisory Committee for Aeronautics has endeavored to interest a number of life and accident insurance companies in the subject of insurance for aviators. At first, only the more prominent companies were approached on the matter. The committee will endeavor to interest all the companies in the United States as far as practicable, and if favorable responses are received, a further bulletin will be issued on this subject.

The following is a digest of the propositions that have so far been submitted to the committee by such companies as have already expressed a willingness to insure aviators:

Aetna Life Insurance Co.

Issues a war permit covering military service in the United States without charge, and beyond the United States for a charge of $50 per thousand. This includes incidental aviation but the company does not care to insure men who are to make a business of aviation and who are not in the military service of the United States. The company desires to place as little restriction upon enlistment and army service as practicable, and consequently, for the present, is carrying the risk of aviation along with army service. Limit of amount which will be written upon army officers and men is $5,000 on commissioned officers, $3,000 on non-commissioned officers, and $2,000 on enlisted men.

Home Life Insurance Co.

Will accept mechanics and others engaged in the manufacture of airplanes and allied work at standard rates. Considering the question of insuring aviators.

John Hancock Mutual Life Insurance Co.

This company has agreed to certain recommendations made by a joint conference of a selected committee of the Insurance Commissioners of the several States and of the officers of the insurance companies, in regard to war conditions. The extra annual premium for the war hazard has been set for the present at $37.50 per $1,000 of insurance. This is a uniform rate and applies to service here as well as abroad or to flying over the water. The company reserves the right to charge an additional premium or to increase the present one whenever circumstances seem to call for such action.

This company will accept army aviators for $1,000 and those in the aviation service who are prohibited from serving as aviators or from flying in any capacity whether as testers, demonstrators or instructors, for the sum of $2,000 to and including ratable age 25. At ages 26 to 35 inclusive, the company will accept on those in the service, other than on those who fly, the sum of $5,000 maximum provided they are single men with dependents, or are married men. To such as are single without dependents, the limit is $2,000. The company will, of course, require suitable evidence that a person in the aviation service is not eligible to serve as a flier, either as pilot, passenger or in any other way, before it can issue more than $1,000.

Mutual Life Insurance Co. of New York

"Regarding men who are employed in connection with aviation but do not go into the air in flying machines, we do or we do not insure such men, according to the circumstances of each case. In some cases, we may think that there is a fair chance of the man in question becoming an aviator, and in such a case we would not issue a policy. If we considered that there was no chance of his becoming an aviator, then we would probably issue him insurance."

National Life Insurance Co.

Men who are employed in connection with aviation, but who do not go into the air, considered on ordinary policies.

New York Life Insurance Co.

Aeronauts, aviators, and men engaged in the manufacture of aeronautic devices, who occasionally fly, provided they do not give exhibitions and do not undertake trick flying, will be considered for a maximum amount of $2,000 with an annual extra premium of $25 per thousand, together with a war clause. The extra premium will be eliminated from the policy one year after they have given up flying either as an occupation or as a pastime, subject to evidence of insurability satisfactory to the company. A refund will be made of the extra premium paid during that year.

The war clause provides for a single extra premium of $100.00 a thousand in event of engaging within two years from the date of issue in any Military, Naval, Red Cross or other relief service outside the boundaries of continental United States. (The boundaries of continental United States are defined to include the waters within three miles of the coast line, but do not include the Panama Canal Zone.) If the insured does not pay the extra premium, and dies within the first two years from date of issue of the policy as the result, directly or indirectly, of engaging in the service already mentioned, the insurance is limited to one-fifth of the face of the policy.

The foregoing provisions would not apply to persons who are in the service of, or who volunteer for service with, a foreign power.

This company does not issue to persons in hazardous occupations the so-called disability benefits or double indemnity benefits.

The Northwestern Mutual Life Insurance Co.

"This company does not insure aviators or persons known to contemplate aviation or likely to engage therein. We do not, however, as to our war service regulations, make any distinction by way of discriminating against those persons who, having entered military or naval service, are attached to the Signal Service branch and engage in aviation." Policies issued prior to April 10, 1917, are entirely free of restriction, but in the case of policies issued subsequently, there is a military or naval service provision, the conditions of which are avoidable only upon payment of such extra premium as the company may require. The extra rate has been fixed temporarily at $50 per thousand, and the same flat rate holds regardless of the branch of service or place of service.

The Prudential Insurance Co. of America

"We are prepared to consider applications for insurance from aeronauts on the basis of what is known in this Company as 'Hazardous Ratings.'

"This would mean an extra premium rate on whole life policies varying from about $8 at the youngest ages to $13 at age 40; on twenty-payment life policies an extra premium of about $10 at the youngest ages and about $13 at age 40; and on twenty-year endowments an extra premium of between $4 and $5 at the youngest ages and about $8 at age 40.

"As an illustration of the gross premium including the extra, the whole life rate at age 25 would be $25.58 per $1,000 of insurance; the twenty-payment life rate, $34.42; and the twenty-year endowment rate, $46.50.

The Travelers Insurance Co.

Will insure aviators attached to The Army or Navy on the same terms as members of any expeditionary force sent abroad. Will not issue accident insurance, but will issue life insurance on the ordinary or higher premium life forms with an additional premium of 10 per cent of the amount of insurance per annum. The amount of insurance is limited to $1,000 an individual.

Union Central Life Insurance Co.

Policy holders subsequently employed as aviators or in connection with aviation will be placed upon the same basis as those entering The Army and Navy.

ACCIDENT INSURANCE FOR AVIATORS

No definite proposition has yet been submitted to the Committee on the subject of accident insurance for aviators.

*Bulletin issued by the National Advisory Committee for Aeronautics, for the information of officers and enlisted men connected with the military and naval air services of the United States.

Aircraft Production Board

The Council of National Defense has issued the following:

The announcement by the Council of National Defense of the creation of an aircraft production board marks the complete formulation of the Government's aircraft policy and the beginning of the work of carrying it into effect. It is the first authoritative statement of America's war policy in the air.

"There are two outstanding factors in modern warfare which the struggle in Europe has brought out," Howard Coffin, chairman of the board and member of the advisory commission of the Council of National Defense, said. "One is the submarine; the other, the airplane. We now believe America has started on the right road toward working out her destiny in the air and taking the place to which her capacity entitles her and which the world expects of her."

3,500 Air Craft This Year

The immediate policy involves roughly a program for the first year of turning out in American factories about 3,500 air machines, including both training and battle types, and the establishment of schools and training fields with sufficient capacity not only to man these machines, but to supply a constant stream of aviators and mechanics to the American forces in Europe. Under the auspices of six of the Nation's leading engineering schools, cadets are already under preliminary training for the American military air service, and negotiations for three of nine training fields now contemplated have been approved by the War Department. Their construction will begin immediately.

The question of the other six sites is now being considered by the department after a personal survey of locations in various parts of the country by department officials. Negotiations on contracts for airplanes are under way, and some necessary orders have already been placed.

Members of the Board

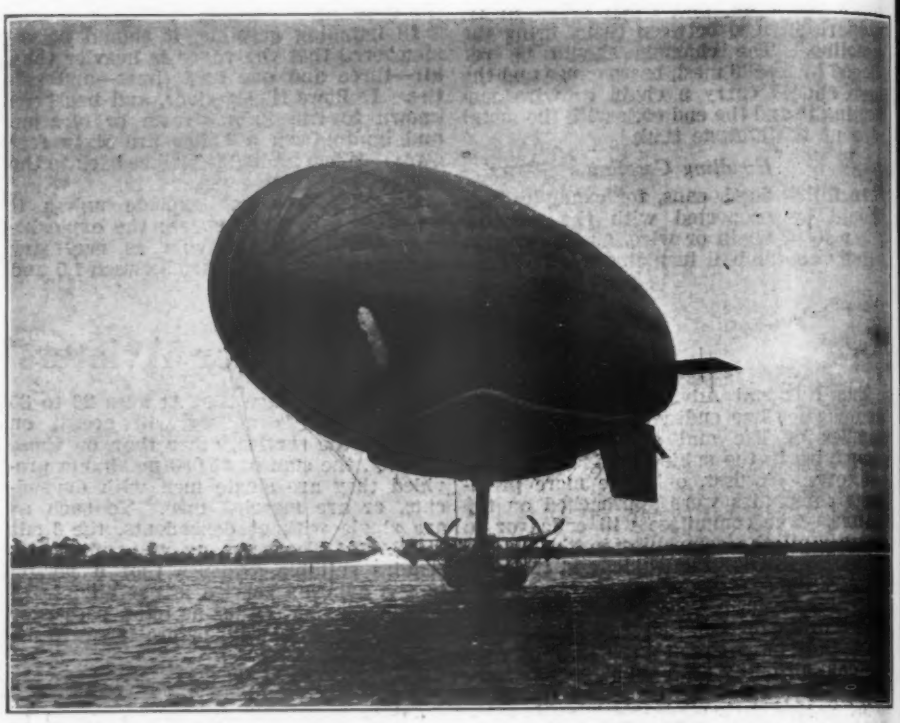
The members of the board besides Chairman Coffin are Brig. Gen. George O. Squier, Chief Signal Officer, U. S. A.; Rear Admiral D. W. Taylor, Chief of the Bureau of Construction, U. S. N.; S. D. Waldon, former vice-president of the Packard Motor Car Co.; E. A. Deeds, of the Dayton Engineering Laboratories Co., and R. L. Montgomery, senior member of the Philadelphia firm of Montgomery, Clothier & Taylor, who will serve as financial and business adviser of the board.

The aircraft production board will act in the closest cooperation with the War and Navy Departments, especially with the recently created Joint Army and Navy Board on Design and Specifications, which has been intrusted by the two Secretaries with discretion on all questions of design and specifications in all forms of military aircraft except Zeppelins. The membership of this joint board includes the following: Major B. D. Foulois, U. S. A.; Captain V. E. Clark, U. S. A.; Lieutenant A. K. Atkins, U. S. N.; Lieutenant J. H. Towers, U. S. N.; Assistant Naval Constructor J. C. Hunsaker, U. S. N.; Captain E. S. Gorrell, U. S. A. Major Henry Souther, the consulting engineer of the Signal Corps, will act in a similar technical capacity to the aircraft board.

Balloon School at New Haven

Instruction in the operation of lighter-than-air machines will be given under the supervision of the War Department at the collegiate balloon school which is to be located at New Haven, Conn. The institution will be the first of its kind in this country and while there is no intimation that special educational qualifications will be required it is expected that a large proportion of those who attend will be students and graduates of colleges. All applicants for admission to the school will be required to pass the physical and mental tests prescribed by the military regulations. It is expected that the school will open with several hundred students in a short time.

The DN-1 Passes Government Tests



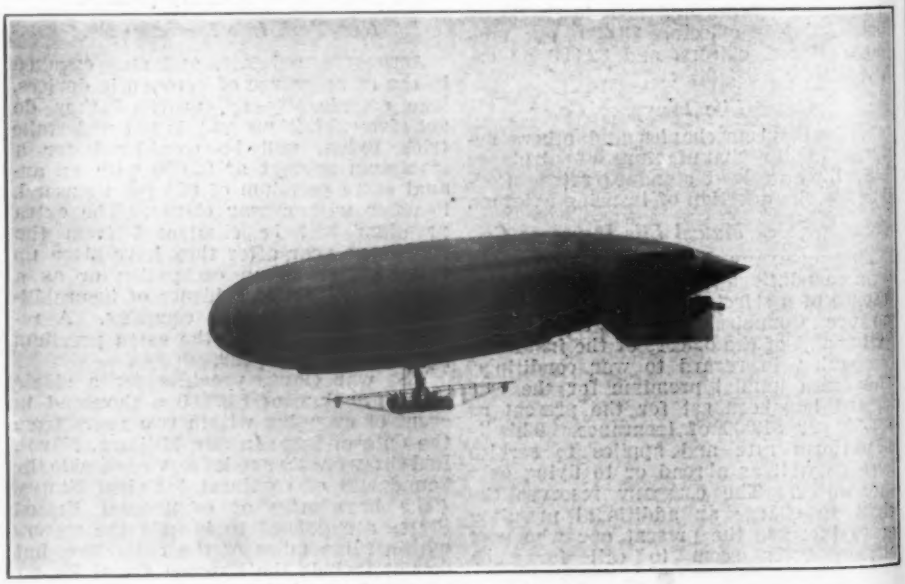
THE DN-1 RESTING ON THE WATER IN THE BAY

The DN-1, built by the Connecticut Aircraft Co. for the U. S. Navy, and the first U. S. Navy non-rigid dirigible has successfully made its test flights at Pensacola.

Under the direction of C. F. Smyth, general manager, and Hans O. Stagel, pilot, of the company, the DN-1, on its first flight, after leaving the floating hangar at the Station, ascended to an altitude of 1,000 ft., crossed the bay, sailed around Santa Rosa Island, circled the city of Pensacola, and after making two landings on the water, returned to the hangar.

The ascents and descents were accomplished entirely by means of the ballonettes, and only 22 gallons of gasoline were required to maintain a cruising speed of 30-35 m.p.h. for the 2 hour flight.

The tests exceeded even the expectations of the builders. Two more non-rigid dirigibles of the same type are now under construction by the Connecticut Aircraft Co. for the Government, and it is expected that they will be completed early in July.



THE DN-1 IN FLIGHT OVER THE BAY

Wireless from Seaplanes

According to the *Naval Flying Corps Monthly*, on a recent flight of five navy seaplanes from Pensacola to New Orleans and return, one of the machines was equipped with a wireless transmitter and messages from the machine were heard at New Orleans during the entire flight.

The radio transmitter was installed on the flagplane of the squadron by B. F. Miessner, Expert Radio Aide. It is stated that the transmission record made was ten miles range per pound of apparatus, against a previous record of one mile per pound.

Aeronautical Specifications No. 1003

Military Pursuit Airplanes

This specification describes the design, construction, equipment and requirements of a military airplane adapted to overland flying, combat, and pursuit of hostile aircraft.

General Requirements

The following characteristics shall be proven to the satisfaction of inspectors appointed by the Government for that purpose:

(1) This airplane shall be a one-place tractor, with one body and shall be equipped with one engine and one propeller.

(2) It shall be designed for carrying a useful load comprising the following:

(a) Pilot—seventy-four (74) kilograms.

(b) Available gasoline and oil sufficient for a flight of two and one-half hours at full power.

(c) Machine gun or guns, ammunition, equipment and instruments—sixty (60) kilograms.

Unless otherwise specified, during all performance and maneuvering tests, the machine guns shall be mounted in place and the useful load carried shall be equivalent to the above enumerated.

(3) The power plant for which the airplane shall be designed shall be an engine of type approved by this office, of between 100 and 150 actual brake horsepower.

(4) The horizontal high speed, at an altitude of 3,000 meters above sea level, shall not be less than 165 kilometers per hour.

(5) Next to extremely rapid climb, a large speed range is desirable. It shall be demonstrated by landing in a calm, that the run after touching is not more than eighty meters, and that the landing speed is not so great as to render the airplane difficult to handle.

(6) The climb shall be not less than 3,000 meters in thirteen minutes.

(7) The airplane shall be capable of attaining in less than thirty minutes (starting with the specified useful load) an altitude of five thousand (5,000) meters.

(8) The run required, in a calm, to "unstick" for flight, shall not exceed sixty-five (65) meters.

(9) The airworthiness and general flying qualities of the airplane shall be satisfactory. *The primary characteristic desired is celerity of response to control,* in other words, extreme handiness.

In order to determine the flying qualities of the airplane, an Army pilot may, at the discretion of the inspectors, after the satisfactory completion of all required performance tests, fly the airplane to determine its general suitability for the use intended.

(10) Maneuvering ability on the ground must be satisfactory. The airplane shall be capable of making reasonably sharp turns to right and left or of being driven along a straight course in any direction with respect to a moderate wind.

(11) Control system shall be of the "stick" type. The operation of the control shall be positive, reliable, mechanically easy and shall give the proper power ratio in each case. The engine throttle shall be on the right hand side. The ground wire switch shall be on the left side.

(12) Satisfactory provision must be made for mounting and firing one or two machine guns (as specified in the order). No provision for training the gun with respect to the airplane, during firing, is desirable. The proposed system of mounting the machine guns shall be submitted to the War Department for approval before installation. The machine gun shall be of a type specified in the order. A suitable arrangement of sights shall be installed.

(13) Gasoline feed to the carburetor shall be by gravity and shall be operative in all normal flight attitudes. It is highly desirable to avoid air pressure in a gasoline tank. In case it is necessary to pump from the main supply tank to the gravity tank, the pump shall be a suction pump. The main supply tank shall be divided into two gas tight compartments. Self sealing tanks are desirable.

Structural Design

Factors of Safety.—Factors of safety will be required as follows: A. Main plane and girder structure. Stress analyses using methods and moduli approved by this office must be made for the high and slow speeds of the airplane. Under the low speed condition the factor of safety shall be, at no point, less than five and one-half (5½). Under the high speed condition the factor of safety shall be, at no point, less than four and one-half (4½). Computation must be based on the total weight with loading as specified above.

B. *Body and Tail Structure.*—Body structure forward of the cockpit shall be designed or a factor of safety of ten (10) over static loading conditions with the propeller axis horizontal. Load to be as stated in paragraph 2.

Body structure in the rear of the cockpit shall be designed to fail under loads not less than those imposed under the following conditions:

(a) Dynamic loading of five (5), as the result of quick turns in pulling out of a dive.

(b) Superposed on the above dynamic loading shall be the load which it is possible to impose upon the elevators, computed by the ollowing formula: $L = (0.005)\ (A)\ (V^2)$. Where A is the total area of the stabilizing surfaces, i. e., elevators and fixed horizontal surface, and V is the horizontal high speed of the airplane. The units are kilograms, square meters, kilometers per hour.

(c) Superposed on this loading shall be the force in the control cables producing compression in the longerons.

C. *Landing Gear.*—The landing gear shall be designed to permit the airplane, fully loaded, to be dropped from a height of .25 meters on a wood floor, tires at normal inflation, without injury. The design and construction of landing gear and tail skid shall be proven satisfactory.

Instruments

1 Compass—Sperry—Creagh-Osborne—Latest Navy type.

1 Aneroid, 15,000 ft. Taylor Instrument Company's latest type.

1 Clock—Chelsea.

1 Rotating rolling map case.

1 Revolution indicator.

Such instruments and controls as may be necessary in connection with the power unit.

GEORGE O. SQUIER,
Brigadier General, C. S. O.
By: ARD. B. BENNET,
Lieut. Col., 17th Infantry.
Office of the Chief Signal Officer,
War Department,
May 1, 1917, Washington, D. C.

Insignia Adopted for All Government Aircraft

The United States Government has adopted as the distinguishing insignia for all its aircraft a white star with red center on a circular background of blue. All American airplanes, seaplanes, captive balloons, and dirigibles will bear this star of the Flying Corps, which combines the red, white, and blue of the national flag.

The Secretary of the Navy has issued a general order providing for the adoption for naval aircraft of this insignia, which is described as follows:

A five-pointed white star inside of a blue circumscribed field, with the center of the star red. The diameter of the circumscribed circle will be equal to the chord of the wing on which the insignia is placed. The diameter of the inner circle will not extend to the inner points of the star by an amount equal to one twenty-fourth of the diameter of the circumscribed circle. The inner circle will be painted red; that portion of the star not covered by the inner circle will be painted white and that portion of the circumscribed circle not covered by either inner circle or star will be painted blue. The shades of red, white, and blue will be the same as those used in the American flag.

How Insignia Are Placed

The order in regard to naval craft continues:

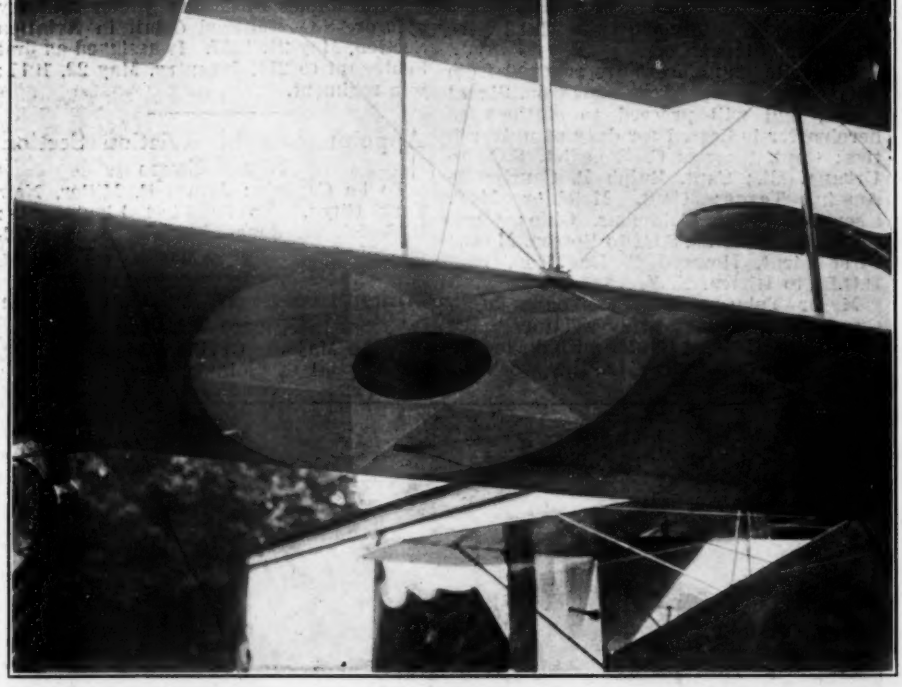
One of each of these insignia will be placed on the upper surface of each upper wing in such a position that the circumference of the circumscribed circle just misses contact with the wing flap. One of each of these insignia will be placed in a corresponding position on the lower surface of each lower wing. Both sides of that portion of the rudder which is in rear of the rudder post will be painted with three equally wide bands, parallel to the vertical axis of the airplane and colored red, white, and blue of the same shades as mentioned hereinbefore, the blue band being nearest the rudder posts, the white band in the center, and the red band at the tail of the rudder.

One of these insignia will be placed on top and one on bottom of gas bags of dirigible balloons, the center of each insignia being in the vertical plane through the fore and aft axis of the gas bag. The center of insignia on top will be sixty feet from forward end and the center of insignia on bottom will be just forward of suspension band. The circumscribing circle of insignia for dirigible will be five feet in diameter. The rudder of each dirigible will be marked in a manner similar to that applied to airplanes, except that stripes will not exceed five feet in length or eighteen inches in width. If there is more than one rudder, only the outboard side of each outboard rudder will be marked.

On Captive Balloons

One of these insignia will be placed on top and bottom of gas bag of captive balloons, the center of each insignia being in the vertical plane through the fore and aft axis of the bag and two and one-half feet aft of the seam joining nose to main body. The circumscribing circle will be five feet in diameter.

The building number of each aircraft will be placed in figures three inches high on each side of the rudder, at the top of the white band hereinbefore mentioned.



THE INSIGNIA ADOPTED BY THE GOVERNMENT, ON THE WING OF AN AIRPLANE—THE CENTER OF THE STAR IS RED, THE POINTS WHITE, AND THE BACKGROUND BLUE

Army Orders

Capt. Joseph C. Morrow, Jr., S.C., designated as Aeronautical Officer, Central Department.

Col. William A. Glassford, retired, having reported for duty, assigned as Aeronautical Officer, Western Department.

Maj. Frank P. Lahm, junior military aviator, S.C., ordered from San Diego, Cal., to Fort Omaha, Neb., to assume command of the U. S. Army Balloon School.

Authority has been given for the organization of the First and Second Reserve Aero Squadrons at New York City and Philadelphia, respectively. The commanding general of the Eastern Department was instructed to complete these units by the assignment of officers and enlisted men from the Aviation Section, S.R.C.

The following officers of the Aviation Section, S.O.R.C., to active duty at Governors Island, N. Y., for duty in connection with the organization of the First Reserve Aero Squadron, Signal Corps; Major Raynal C. Bolling, Capt. Philip A. Carroll, Capt. James E. Miller, First Lieuts. Daniel R. Noyes, Frederick T. Blakeman, Charles Reed, Hobart A. H. Baker and Edwin M. Post, Jr.

First Lieut. Fred A. Post, Aviation Section, S.O.R.C., to active duty at Fort Omaha, Neb.

First Lieut. Edward R. Kenneson, Aviation Section, S.O.R.C., to active duty at Princeton, N. J.

A board of consist of Col. William A. Glassford, retired; Lieut. Col. Thomas T. Slavens, Q.M.C., and Capt. Richard Park, C.E., to meet at San Francisco to make definite recommendation for a site within the appropriation allowed for the Signal Corps Aviation School, San Diego, Cal.

The following officers are relieved from duty at San Diego, Cal., to the stations as hereinafter indicated: First Lieut. Arnold N. Krogstad, 22d Inf., to Berkeley, Cal., for duty at the University of California. Capt. John N. Reynolds, C.A.C., and First Lieuts. Harry M. Brown, 22d Inf.; James R. Alfonte, Inf., D.O.L.; Michael F. Davis, Inf.; Patrick Frissell, 11th Inf., and Adlai H. Gilkeson, Inf., to Columbus, N. M., for duty with the First Aero Squadron, Signal Corps. First Lieuts. Hubert R. Harmon, C.A.C.; Jack W. Heard, 17th Cav., and Whitten J. East, Inf., to Fort Sam Houston, Texas, for duty with the Third Aero Squadron, Signal Corps.

The following officers are relieved from duty with the First Aero Squadron, Signal Corps, and will proceed to stations as hereinafter indicated for duty at universities: Capt. Charles C. Benedict, S.C., to Urbana, Ill.; Capt. Ralph P. Cousins to Austin, Texas; Capt. Melchior McE. Eberts, S.C., to Columbus, Ohio; Capt. Benjamin W. Mills, S.C., to Boston, Mass.; First Lieut. Howard C. Davidson, Inf., D.O.L., to Ithaca, N. Y.

Major Tulasne and Lieutenant de la Grange, two French army aviators, have reported to General Squier with a view to offering their services in the work of building up the American aviation service. The visiting officers have been assigned desks in the office of the C.S.O.

The following junior military aviators, S.C., from duty with the First Company, Second Aero Squadron, S.C., and will take first available transport for the United States for further orders: Capts. Douglas B. Netherwood, Earl L. Canady and Leslie MacDill.

The following aviation officers are assigned to and will join their respective organizations at Fort Sam Houston, Texas; Third Aero Squadron, S.C., Capt. Maxwell Kirby, U.S.A.; Fourth Aero Squadron, S.C.; Capts. B. M. Atkinson and G. E. A. Reinburg, U.S.A., and First Lieut. B. R. Osborne, Aviation Section, S.O.R.C.; Fifth Aero Squadron, S.C., Capts. Carl Spatz and T. J. Hanley, U.S.A., and First Lieut. E. W. Bagnell, S.O.R.C

Capt. James F. Byrom, junior military aviator, S.C., relieved detail in Aviation Section, May 21, 1917. Is assigned as first lieutenant to 21st Infantry, May 22, 1917; join regiment.

Appointments in Aviation Section Signal Corps

To be Captain: James E. Miller, New York City;. To be First Lieutenants: Roderick H. Jones, Buffalo, N. Y.; Edwin M. Post, Tuxedo Park, N. Y.

Appointments in Aviation Section Signal Officers Reserve Corps

To be Majors: Orville Wright, Dayton, O.; Raynal C. Bolling, New York City; Robert Glendinning, Philadelphia, Pa.; Henry Souther, Gloucester, Mass.

To be Captains: Thomas S. Baldwin, Newport News, Va.; Philip A. Carroll, New York City; Ralph L. Taylor, Stamford, Conn.; W. Starling Burgess, Marblehead, Mass.

This giant Government seaplane, weighing 2½ tons, has just been built by the Standard Aero Corporation and is shown on their factory floor. It has a wing span of 70 ft.; it is 14 ft. high and 34 ft. overall length. It is driven by two 140 hp. engines and is expected to develop a maximum speed of 80 m.p.h. and low speed of 45 m.p.h. Machine guns are to be mounted over both the observer's seat, which can be seen in front, and the pilot's seat just to the rear of the plane. The machine is a bomb-dropping battleplane. As shown, it has not been covered with Irish linen, which is the only addition necessary to make it complete and ready for shipment somewhere in the Southern district.

THE HANGARS AND MACHINE NO. 1 OF THE PRINCETON AVIATION CORPS

Walden-Hinners Co. Organized

The Walden-Hinners Co. of Edgewater, N. J., has been organized to build military types of land and water aircraft. The company is now constructing machines and is installing additional equipment for quantity production.

The association of Dr. Henry W. Walden with this company will recall some interesting details connected with the development of aeronautics in this country. Dr. Walden began his experimental work in 1908. In 1910 he and Capt. Baldwin erected airplane sheds at Mineola, L. I. Dr. Walden was a contestant in the international races in 1911 at Nassau Boulevard, L. I. His monoplane was equipped with a 40 hp. Hall-Scott engine, which drove it at a speed of 63 miles per hour.

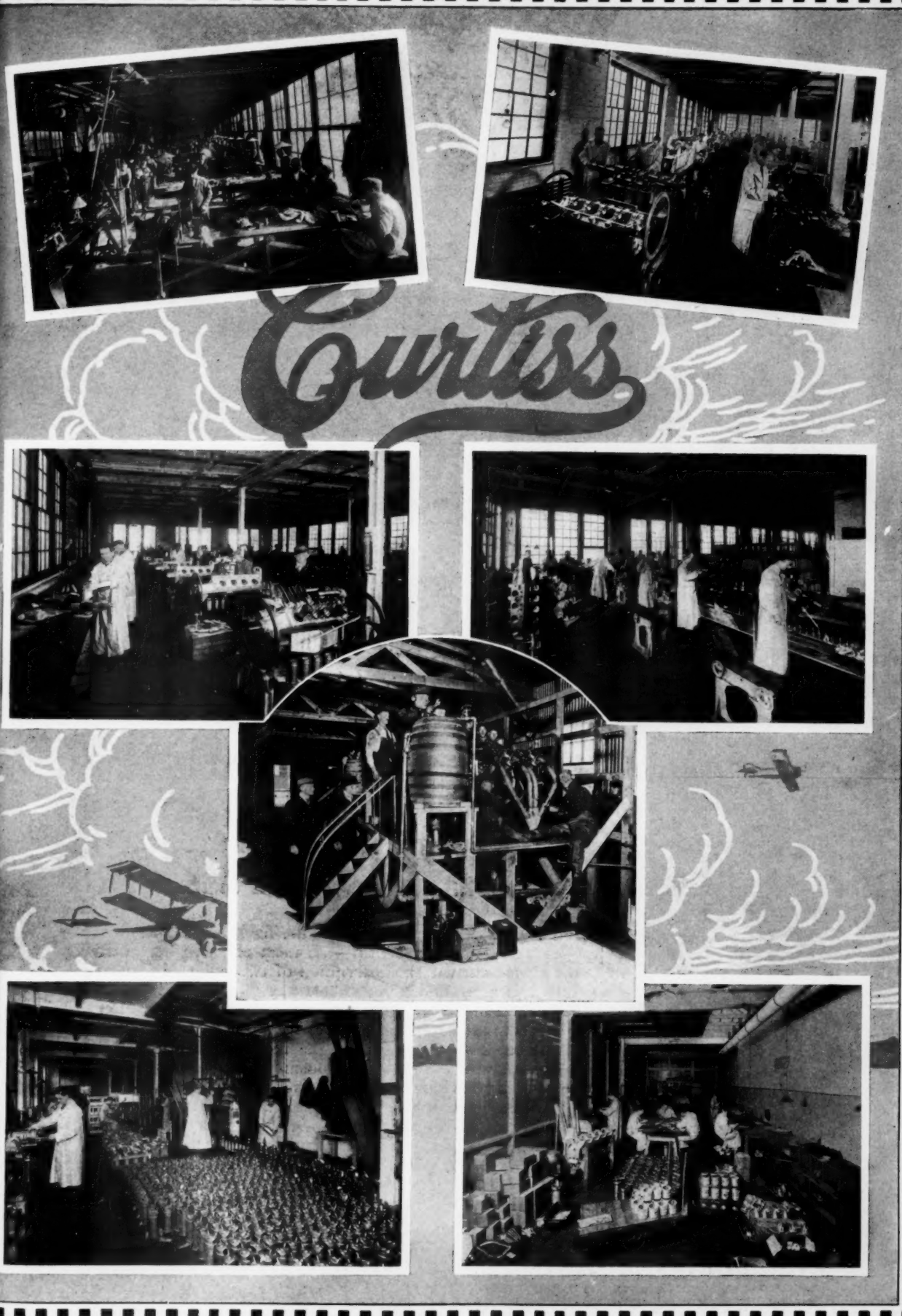
The plant and property of the Walden-Hinners Co. is situated directly across the Hudson from Grant's Tomb, with easy access to water and railroad facilities. The capital stock of the company is owned by individuals composi .g the Walden-Hinners Co. and none of it is for sale.

Fort Omaha Notes

Major Frank P. Lahm, who has been acting as Secretary of the Aviation School at San Diego, has been designated as Commander of the Balloon School at Fort Omaha. His assistant will be Lieut. F. H. Post.

Kite balloons are being sent up every day at the fort, the altitude being gradually increased each day, and the time in the air also being lengthened. An altitude of 2,000 feet has been reached by the observation balloons.

Leo Stevens, civilian instructor, recently had as observers Captains Bower, Geiger and Vaugh and Lieut. Jouett, on a flight starting at midnight. They made a successful landing at daylight near Des Moines, about 125 miles distant from the fort.



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Stand Behind the Men
Behind the Guns

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AND

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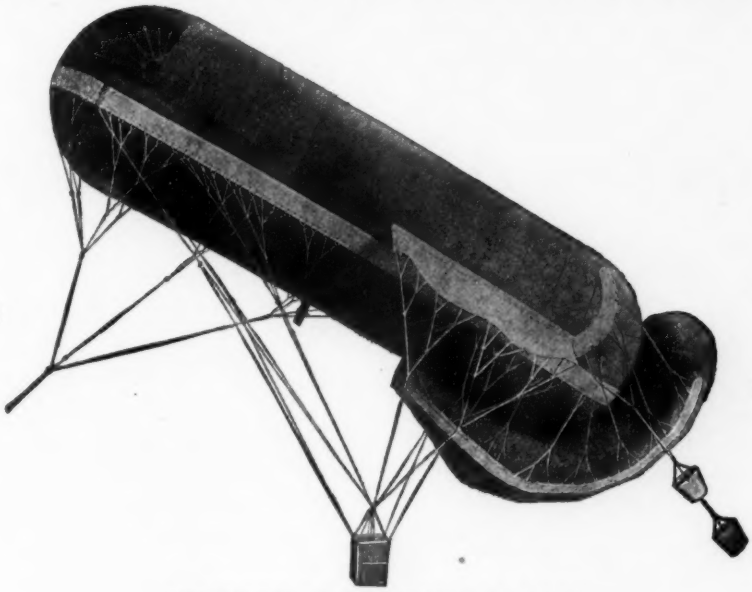

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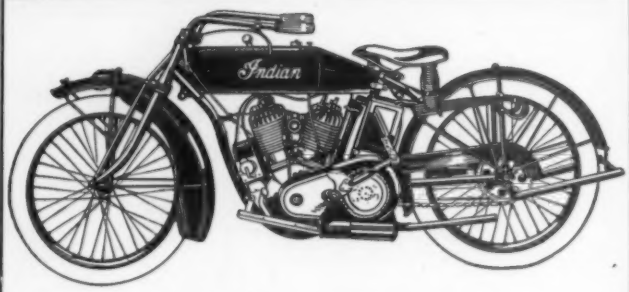

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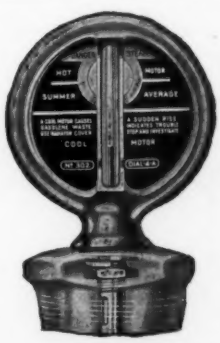

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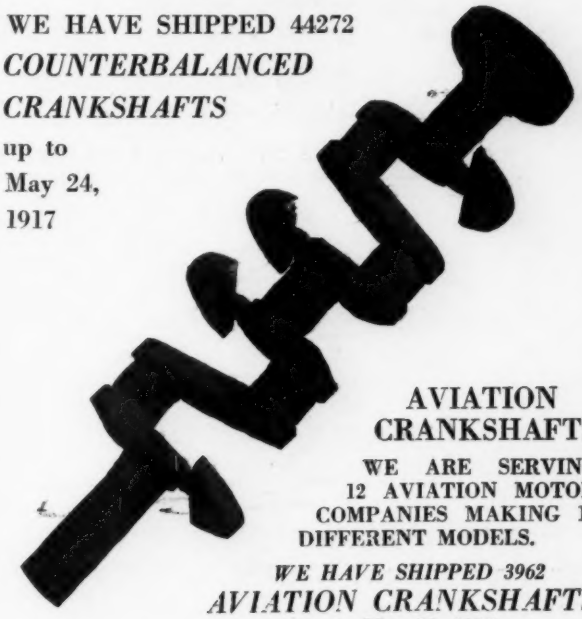

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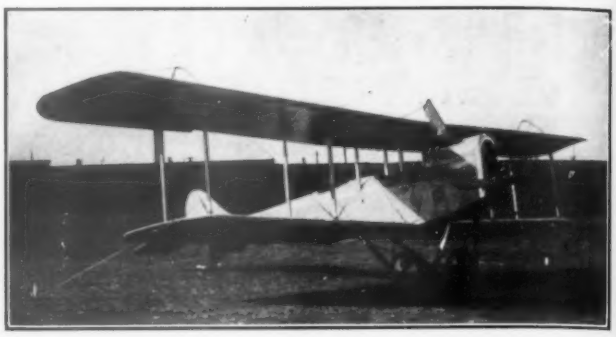

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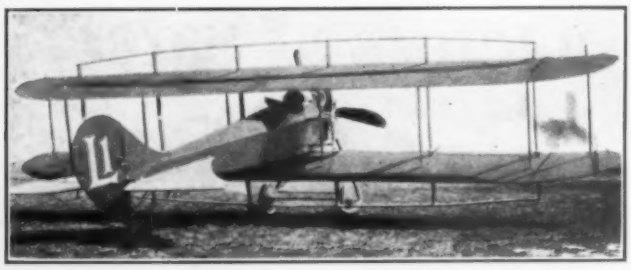

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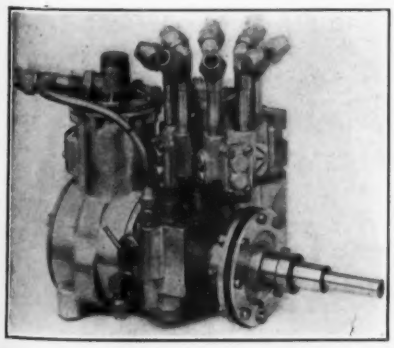

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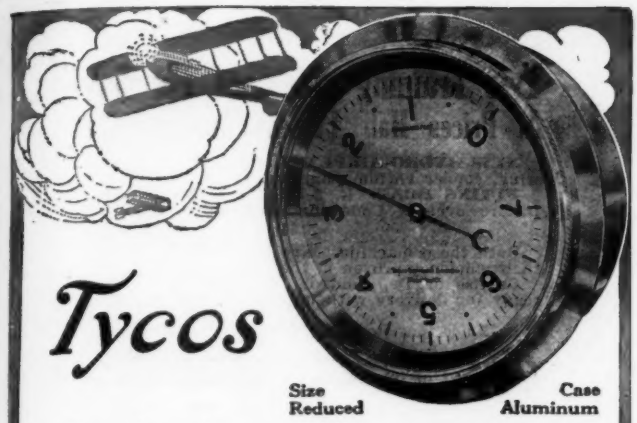

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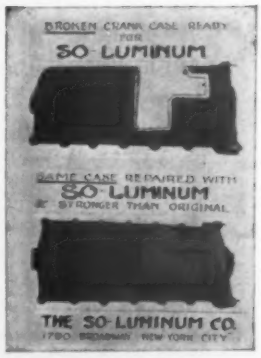

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Curtiss Aeroplane and Motor Corp.
Duesenberg Motors Corp.
General Ordnance Co.
General Vehicle Co.
Gyro Motor Co.
Hall-Scott Motor Car Co.
Harriman Aircraft Motors Co., Inc.
Knox Motors Co.
Maximotor Co.
Miller, Harry A., Mfg. Co.
New Jersey Aeroplane Co.
Orlo Motor Co.
Packard Motor Co.
Roberts Motor Mfg. Co.
Sterling Engine Co.
Sturtevant, B. F., Co.
Taft Pierce Mfg. Co
Thomas-Morse Aircraft Corp.
Union Gas Engine Co.
Wisconsin Motor Mfg. Co.
World's Motor Co.
Wright-Martin Aircraft Corp.

AIRPLANE PARTS
Chicago Aeronautical Supply Co.
Erie Specialty Co.
Rogers Construction Co.

ALUMINUM
Aluminum Castings Co.
Aluminum Co. of America
American Metal Co., Ltd.
So-Luminum Mfg. & Eng. Co. (Solder)

AVIATION SCHOOLS
America Trans Oceanic Co., The
Beam School of Aviation
Christofferson Aviation School
Curtiss Training Schools
Davenport Aviation School
Dodge School of Aviation
Hall Flying School
Kendrick, B. H.
Riverside Aircraft Co.
Stinson School of Aviation
Thomas-Morse Aircraft Corp.
Williams Aviation School
Wright Field Co.

BALL BEARINGS
Hess-Bright Mfg. Co.
New Departure Mfg. Co.
Norma Company of America.
S. K. F. Ball Bearings

BALLOONS AND DIRIGIBLES
Connecticut Aircraft Co.
Custer Specialty Co. (Statoscope)
French-American Balloon Co.
Goodyear Tire and Rubber Co.
Janney-Steinmetz and Co. (Hydrogen Cylinders)
United States Rubber Co.

BAROGRAPHS AND BAROMETERS
Green, Henry J.
Haustetter, A.
Sussfield & Lorch
Taylor Instrument Companies

BATTERIES
Electric Storage Battery Co.

BEARING METALS
American Bronze Co.
Fahrig Metal Co.
Magnolia Metal Co.

CARBURETORS
Miller Carburetor Co.
Stromberg Motor Devices Co.
Wheeler and Schebler
Zenith Carburetor Co.

CLOCKS AND WATCHES
Ingersoll, Robt. H., and Bro.
Chelsea Clock Co.
Depollier, J., & Son
Waltham Watch Co.

CLOTHING
Abercrombie & Fitch
Meyrowitz, E. B. (goggles)
N. Y. Sporting Goods Co.
Rogers, Peet & Co.
Sanders Co.
Spaulding, A. G., & Bros.

COMPASSES
Sperry Gyroscope Co.
Taylor Instrument Companies

DOPE AND VARNISH
Adams & Elting Co.
American Emaillite Co.
Chemical Products Co.
Conover, The C. E., Co.
DuPont Chemical Works
Flexible Compound Co.
National Aeroplane Co.
Pratt & Lambert
Standard Varnish Works
Valentine & Co.
Weeks & Co.

DRIFT INDICATOR
Sperry Gyroscope Co.

DYNAMOMETER
Sprague Electric Works

ENGINE PARTS
Allegheny Forging Co.
Burd High Compression Ring Co.
Doehler Die Casting Co.
Erie Specialty Co.
Fibre Finishing Co.
Gifford, Leland Co.
Gill, P. H., & Sons
Hydraulic Pressed Steel Co.
Levett, Walker M., Co.
Park Drop Forge Co.
Standard Parts Co.
Taft-Pierce Mfg. Co.
Tioga Steel & Iron Co.
Williams, J. H., & Co.
Wyman-Gordon Co.

EXHIBITION COMPANIES
The Cessna Exhibition Co.
Granburg, Gustav
Miller Aeroplane Co.
Weeks-Smalley Co.

FABRICS
Courtrai Mfg. Co.
Lamb, Finlay & Co.
McBratney, Robt. & Co.
Scott, Hutchison Co.
Whitman, Clarence & Co.

FIRE EXTINGUISHERS
Fyr-Fyter Co., The
Johns-Manville Co., H. W.
Pyrene Mfg. Co.

GASKETS
Fibre Finishing Co.

GLUE
Ferdinand, L. W., & Co.
Baeder & Adamson.

GAGES
Crosby Steam Gage & Valve Co.
Foxboro Co., The, Inc.
United States Gage Co.

HANGARS
American Bridge Co.
Anchor Corrugating Constr. Co.
Ashley Steel Bldg. Co.
Howell, Field & Goddard, Inc.
Keasby & Mattison
Milliken Bros.
Virginia Bridge & Iron Co.

LIFE PRESERVERS
Universal Safety Mattress Co.

LUMINOUS COMPOUND
Cold Light Mfg. Co.
Radium Dial Co.
Radium Luminous Material Corp.

MAGNETOS
Bosch Magneto Co.
Berkshire Magneto Corp.
Ericsson Mfg. Co.
Remy Electric Co.
Splitdorf Electrical Co.

METALS
American Vanadium Co.
Acieral Co. of America (Aluminum Steel)
Bethlehem Steel Co.
Detroit Pressed Steel Co.
Federal Pressed Steel Co.
Garland Ventilator Co.
Gueder, Paeschke & Frey Co.

MODEL AIRPLANES
Ideal Aeroplane Supply Co.
Wading River Mfg. Co.

MOTORCYCLES
Excelsior Motor Mfg. Supply Co.
Harley-Davison Co.
Hendee Mfg. Co.
Henderson Motorcycle Co.

OILS AND LUBRICANTS
Baker Castor Oil Co.
Graphite Lubricant Co.
Gulf Refining Co.
Sheppard Ideal Oil Co.
Standard Oil Co.
Texas Co.
Vacuum Oil Co.

OIL PUMPS
Wayne Oil Tank & Pump Co.

ORDNANCE
Buck Air Craft and Munitions Co.
Colt Firearms Co.
Driggs-Seabury Ordnance Corp.
General Ordnance Co.
Maxim Silencer Co.
Savage Arms Co.

PACKING
Fibre Finishing Co.

PHOTOGRAPHY
Brock, Arthur, Jr.
Herbert & Huesgen Co.

PONTOONS
Niagara Boat Co.
Welen Marine Equipment Co.

PROPELLERS
American Propeller & Mfg. Co.
Aviauto Mfg. Co.
Buffalo Aeroplane Corp.
C. M. O. Physical Laboratory
Excelsior Propeller Co.
Schweizer & West Mfg. Co.
Washington Aeroplane Co.

PYROMETERS
Foxboro Co., The, Inc.
Shore Instrument & Mfg. Co.
Taylor Instrument Companies

RADIATORS
Ajax Auto & Aero Sheet Metal Co.
A-Z Co.
Bush Mfg. Co.
El Arco Radiators Co.
Livingston Radiator Co.
Rome-Turney Radiator & Mfg. Co.
The English & Mersick Co.

SCELEROSCOPE
Shore Instrument & Mfg. Co.

SEA SLEDS
Murray & Tregurtha

SHOCK ABSORBERS
Wood, J. W. Elastic Web Co.

SPARK PLUGS
Champion Ignition Co.
Johns-Manville Co., H. W.
Pyro Ignition Co.
Rajah Auto Supply Co.
Splitdorf Electrical Co.

SPEED INDICATORS
Foxboro Co., The, Inc.
Johns-Manville Co., H. W.
Stewart Warner Speedometer Corp.

STABILIZERS
Greene Aeronautical Co.
Martin Arodynamic Stabilizer.
Sperry Gyroscope Co.

STARTERS
Bijur Motor Lighting Co.
Christensen, The, Engineering Co.
Dayton Engineering Laboratories Co.
Motor Compressor Co.
Northeast Electric Co.
Wagner-Hoyt Electric Co.

TACHOMETERS
Johns-Manville Co., H. W.
Nelson Blower & Furnace Co.
Queen-Gray Co.
Stewart Warner Speedometer Corp.
Veeder Mfg. Co.

TANKS
Janney, Steinmetz & Co.

TELEPHONES
General Accoustic Co. (Aviaphone).
Streator Electric Co.
Telautograph Corp.
Western Electric Co.

THERMOMETERS
Foxboro Co., The, Inc.
Taylor Instrument Companies

TIRES AND RUBBER
Goodyear Tire & Rubber Co.
Hodgman Rubber Co.
United States Rubber Co.

TOOLS
Browne & Sharpe
Cooper, The John D., Aeroplane Co.
Hall-Scott Motor Car Co.

TRUCKS AND TRAILERS
Federal Motor Truck Co.
Four Wheel Drive Auto Co.
Nash Motors Co.
Packard Motor Car Co.
Sechler & Co., The
Service Motor Truck Co.
White Co.

TUBING
Empire Art Metal Co.
Frasse, Peter A., & Co.

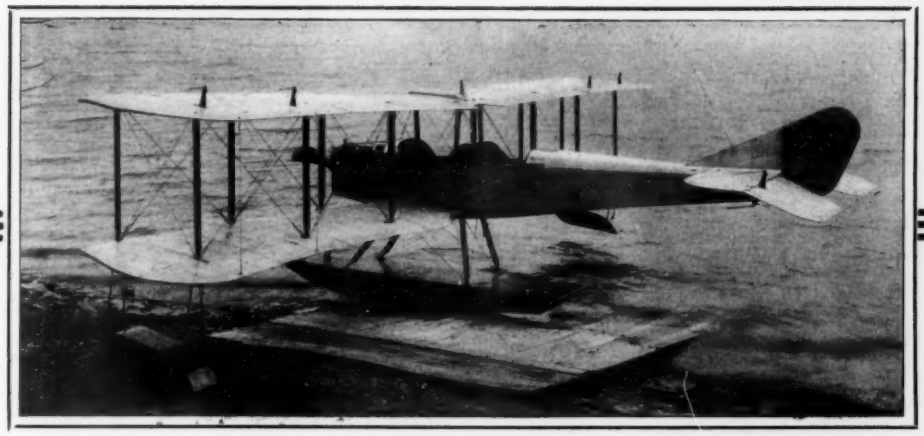
TURNBUCKLES
Aero Mfg. & Accessories Co.
Ajax Iron Works
C. E. Aeroplane Works
Dilliner-Meyer Mfg. Co.
Erie Specialty Co.
National Aeroplane Co.
New York & Hagerstown Metal Stamping Co.
Standard Screw Co.

WHEELS
Ackerman Wheel Co.

WIRE
American Steel and Wire Co.
Electric Cable Co.
Roebling's, John A., Sons
Simplex Wire and Cable Co.

WIRELESS
American Radio & Research Corp.
American Wireless Tel. Co.
Cutting & Washington.

WOODS
Alcock Co., John L.
American Balsa Corp.
Chetham Lumber Co.
Delatour, J.
Dutton, A. C. Lbr. Corp.
Ludlow, Israel
Mengel, C. C., & Bros. Co.



THOMAS NAVY HYDROAIRPLANE, TYPE SH-4.

THIS **machine** has been designed **particularly** for **training purposes,** for either **land or water use.** Good inherent stability is secured by careful balance and moderate dihedral wing setting. **Control surfaces** are of **generous dimensions** to insure **ease of handling** under all conditions.

Speed range 40 to 65 M. P. H. with 100 H. P. engine

Contractors to U. S. Army and Navy

THOMAS-MORSE AIRCRAFT CORPORATION

SUCCESSORS TO THOMAS BROS. AEROPLANE CO., INC. THOMAS AEROMOTOR COMPANY, INC. *ITHACA, N. Y.*

BURGESS PRIMARY TRAINING TRACTOR, TYPE B. P.

This machine was designed by W. Starling Burgess at the request of the United States Army for a primary training tractor airplane having a practical side by side seating arrangement with duplicate controls.

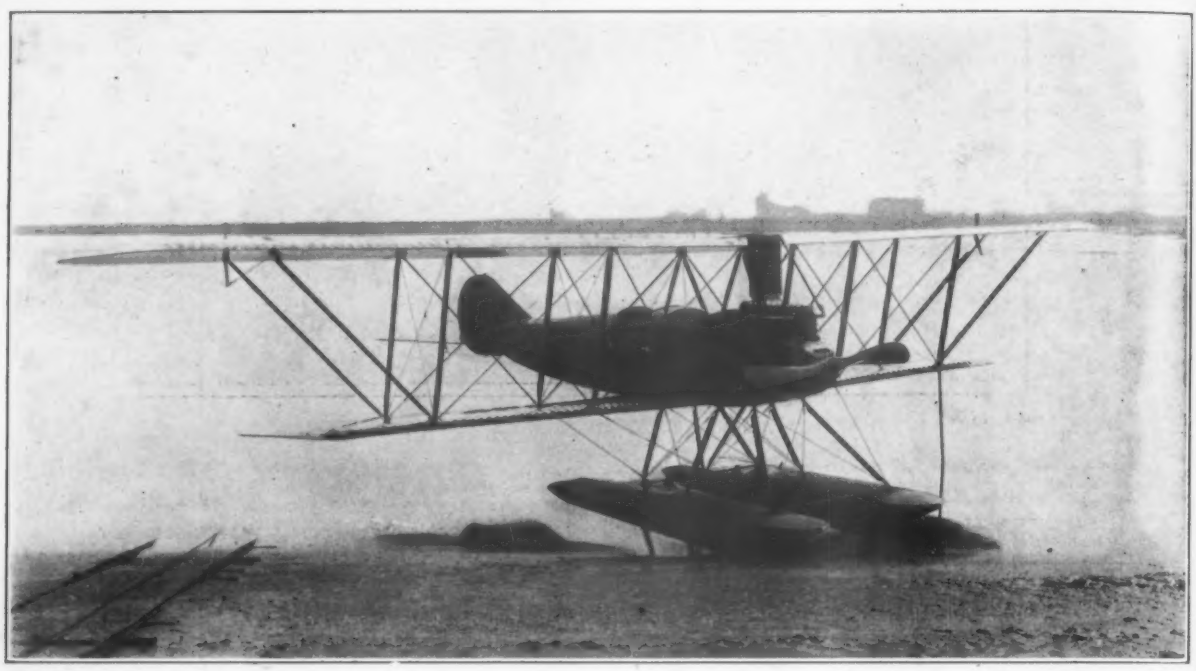
This has been accomplished without sacrificing in the least the efficiency or appearance of the machine.

It fills the urgent need found at present in the aviation schools—giving great range of control and allowing the instructor to be at side of the pupil during flight, thereby facilitating instruction.

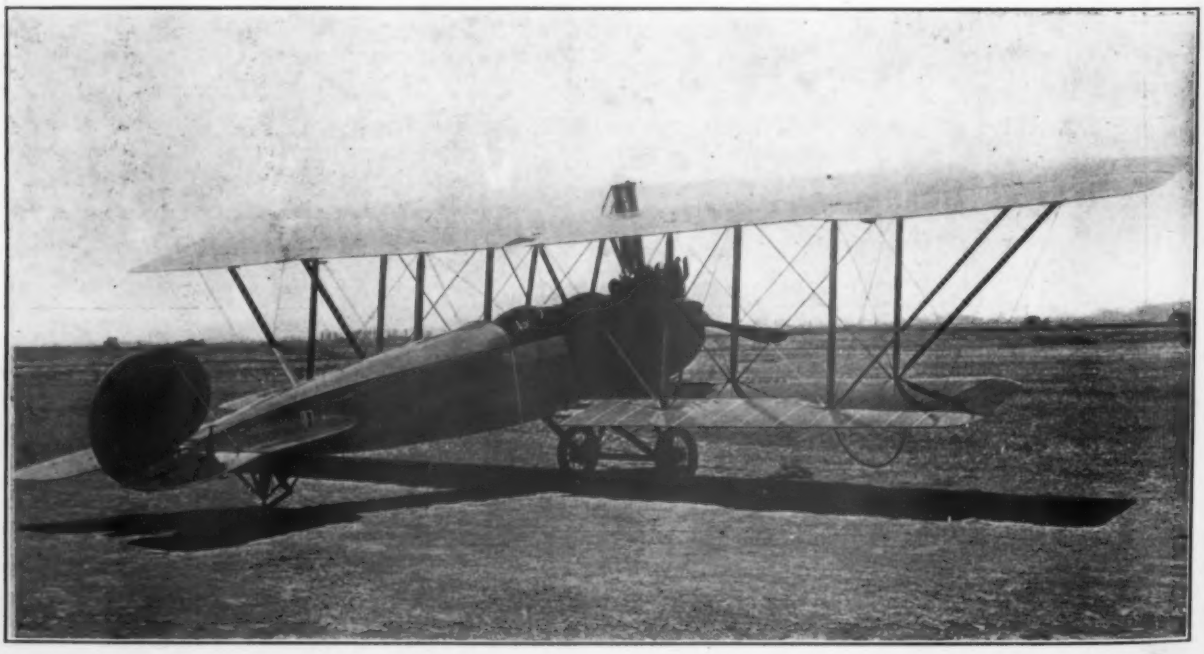
This has been proven very satisfactorily in experimental flights as well as in the official trials through which this machine passed with great success.

THE BURGESS COMPANY, Marblehead, Mass.

MANUFACTURERS OF THE BURGESS-DUNNE AND BURGESS SEAPLANES
SOLE LICENCEES FOR THE DUNNE PATENTS



THE MARTIN TWO PLACE
RECONNAISSANCE TRACTOR
MODEL R
Convertible Land and Water

Ordered by
the United States Army and Navy

Wright-Martin Aircraft Corporation